THE MORPHOLOGY AND LIFE HISTORY OF LEPTOCORISA VARICORNIS FABRICIUS (COREIDAE, HEMIPTERA) A SERIOUS PEST OF PADDY CROP IN INDIA

THESIS PRESENTED

FOR

THE Ph.D. DEGREE

of

The Aligarh Muslim University.

SUBMITTED BY

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JUNE, 1954.

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C O N T E N T S

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1. INTRODUCTION

The morphological study of the group Heteroptera in general and the members of the family Coreidae in particular has not been given due consideration by many Indian workers although the subject has been touched in bits by many foreign workers in the past. The economic significance of the Indian species of this group has encouraged the researchers to confine their observations on the life history alone. Moreover, a comprehensive account on the morphology of terrestrial Heteroptera has been put forth neither at home nor abroad for the last twenty years. It was, therefore, one of the main objects of the present research to set out the facts relating to the morphology of Leptocorisa varicornis Fabr. At the same time it was considered necessary not to neglect altogether another important aspect of its study namely the life history. The problem 'Morphology and life history of Leptocorisa varicornis Fabricius (Coreidae, Hemiptera)' was accordingly taken up for the Ph.D. degree of the Muslim University, Aligarh.

On the other hand, Leptocorisa varicornis is one of the major pests of paddy crop and is found in abundance at Aligarh and adjoining areas. It is also widely distributed in practically all the rice growing regions of the subcontinent. It is, therefore, easily available and can be selected as a type for detailed morphological and biological studies in the laboratory as well as in the field.

Somewhat scattered matter is available on the special parts of the body of Hemiptera such as Spooner's (1938), Butt's (1943), MacGill's (1947) and Quadri's (1951) papers on the head capsule; Malouf's (1932) and Brindley's (1933-34, 1938) papers concerning the thorax and Pruthi's (1925) on the male genitalia. Papers dealing with more extensive and detailed studies of a single species are very rare. Of these the following are some of the indispensable contributions.

(1) Hamilton (1931) - Morphology of water scorpion.

(2) Myers (1928) - Morphology of cicada.

(3) Quadri (1950) - Biology, life history and external and internal anatomy of Pyrilla perpusilla.

(4) Tower (1914) - External anatomy of squash bug, Anasa tristis.

A considerable amount of attention has been paid by the author to present as detailed study of the morphology and life history as possible. It has been found profitable from the point of elucidation to divide the present work into :-

(i) Skeleto-muscular mechanism of the entire body,

(ii) Internal anatomy, and

(iii) Life history.

The skeleto-muscular mechanism deals with a detailed study of the various sutures and sclerites of the head, thorax, abdomen and their appendages. At the same time much stress has been laid on the study of myology since it affords a stable

method of approach for clear understanding of the working of various parts.

An extensive study of the internal anatomy has also been made. It elucidates the general organization of the different systems and the histology of important organs.

A detailed study of the life history has not been ignored. It was also keely felt to study the post-embryonic development of the chitinous structure of the whole body, without the knowledge of which, it was apprehended, the life history may not be complete.

×Finally, the description of the various parts has been fully illustrated with suitable diagrams, since in the opinion of the writer if the presentation of diagrams is improper and the labelling inadequate it becomes very difficult to get anything out of the matter.×

2. MATERIAL AND TECHNIQUE

The adult insects were collected by means of hand nets from the paddy fields. These were then transferred to Picro-chlor-acetic fixative and after about twelve hours were washed several times with 70% alcohol to remove the traces of Picric acid. These were finally kept in 70 % alcohol. The insects preserved in this fixative gave quite satisfactory results for morphological and histological studies for a considerable long period.

A thorough study of the adult insect was then made by dissecting the various parts under binocular. The sclerotized structures comprising the various sclerites and the genitalia were studied by treating the material with 10 % Potassium hydroxide (KOH) solution. It was then washed several times with water. The decoloration was done by Potassium Chlorate ($KClO_3$) and concentrated hydrochloric acid (conc. HCl). In order to avoid any distorsion by the acid, the material was brought in contact with the fumes (chlorine gas). The decolourised part was then thoroughly washed with water, stained with Carbol-aniline and dehydrated in ascending grades of alcohol. The material was finally treated with Carbol-xylol to ensure complete dehydration and the details were made out under the microscope.

The musculature of the adult has also been examined thoroughly in preserved specimen. The material was then stained in Mallory's fluid or Borax carmine. The former gave more satisfactory results, being quicker in imparting a bright colouration to the tissues and also in tracing out the exact points of origin and insertion of the muscle fibres.

The internal anatomy was studied both in preserved and fresh insects. Borax carmine was used for staining the alimentary canal, malpighian tubules, brain, ventral nerve cord and male and female reproductive organs. Mallory's stain was found more helpful in tracing the course of diaphragm muscles and branches of the tracheae.

The histology was studied by section-cutting. The material after being dissected out from the preserved specimens was subjected to dehydration in ascending grades of alcohol. It was then kept for about half an hour in a mixture of approximately equal parts of alcohol and Benzene. The final clearing was done in pure Benzene. The material was subsequently transferred to a mixture of Benzene and Paraffin and was left in the thermostat for about 2-3 hours. It was then given two changes in pure Paraffin of 56-58°C melting point, each after an interval of one hour. The material was then embedded and sectioned at 6-8 microns with the help of Cambridge Rocking microtome. The sections were stained in freshly prepared Heidenhain's Iron Haematoxylin and the proper differentiation was made out in 1 % and 2 % Ferric alum " $(NH_4)_2SO_4$ $Fe_2(SO_4)_3$. 24 H_2O " solution. The sections were then thoroughly washed in running water for about twenty minutes. These were later on passed through the ascending grades of alcohol upto 90 % and then counterstained with Eosin. The sections were finally transferred to absolute alcohol and xylol before mounting in Canada balsam.

ACKNOWLEDGEMENT

It is with much pleasure that the writer acknowledges his gratefulness and indebtedness to Dr.S. M. Alam, under whose guidance this work has been successfully carried out, for his several valuable suggestions and criticism. He is also under great obligations to Prof. M. B. Mirza for providing all facilities for research work and financial help. The author is also thankful to the Agricultural Research Institute, New Delhi, for the identification of the insect.

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SKELETO-MUSCULAR MECHANISM

OF

LEPTOCORISA VARICORNIS FABR.

I. THE HEAD

(i) External features of the head capsule.—

The triangular head capsule (Fig.1) of Leptocorisa varicornis Fabr., is of prognathous type. This condition enables the facial surface to assume dorsal position, while the ventral surface is drawn forward and develops the gular area. The post-occipital region (Figs.1, 2, 3, 4, 16, 24, 27, 28, 33 and 34:Poc) forms the base while the clypeus (Figs.1 and 2; Clp) becomes the apex of the triangle. The two large globular compound eyes (Figs.1, 2, 3, 16, 24, 27, 28, 33 and 34; E) and the long filiform antennae (Fig.6) form its lateral limitations. The elongated beak (Figs.2 and 17; Lb) with bristles, on coming out from the apex of the head, bends back to lie underneath the thorax. Posteriorly the head capsule possesses a wide circular foramen magnum (Fig.4;Fmg) which is limited dorso-laterally by the postoccinut (Figs.1, 2, 3, 4, 16, 24, 27 and 28; Poc) and ventrally by the proximal portion of the gular plate (Figs.2 and 3; Gu). This opening functions as a communicating passage between the head and thorax. The mid-dorsal portion of parietals in the vicinity of the formation of frontal sutures possesses a pair of ocelli (Figs.1 and 2; O). This area on the basis of its own position, as well as, presence of ocelli in it, can be compared with the "vertex" region of a hypognathous head capsule.

(ii) Sutures of the head capsule.—

The following sutures are marked off in the head capsule.

The epicranial suture.- (Figs.1 and 2) The epicranial suture is developed in the form of an inverted 'Y' with the stem crossing mid-dorsally on the top of the head and the arm diverging antero-laterally. The dorsal part commonly known as the 'coronal suture' (Figs.1 and 4; Cs) is long and starting from the dorsal margin of the foramen magnum, extends mid-longitudinally over the postoccipital and occipital regions. It is visible externally as a non-pigmented double line running parallel to each other due to the formation of a mid-longitudinal groove (Fig.1; Cs + mcs) in the cranium. Externally this inflection forms the mid-cranial sulcus (Fig.2; mcs) which occupies a position normally traversed by the coronal suture. Posterior to the epistomal suture is placed mesally a horizontal groove (Fig.1;mcs) which, besides giving regidity to the frontal plate, provides attachment to one of the antennal muscles as well. This inflection appears to be a continuation of the mid-cranial inflection (Figs.16 and 24; mci) which has become suppressed in the middle of the frontal plate. The frontal sutures (Figs.1 and 2; fs) arise from the coronal suture between the two ocelli. It extends antero-laterally between the two compound eyes to end close to the antennal sockets.

Recently DuPorte (1946) and Snodgrass (1947) have shown that the 'epicranial suture' has no morphological importance since it is a line along which the cuticle of the head breaks during ecdysis. Moreover, its arms are not of constant feature and vary in their course in different insects. Besides, they have described the presence of few other elements which are entirely different from the 'epicranial suture'. In view of these facts it has been suggested by them to give up the term 'epicranial suture' and distinguish it as the 'ecdysial line or suture' of the head. The present writer agrees to it and suggests to consider the so-called epicranial suture in Leptocorisa varicornis as 'ecdysial line' extended over the head with coronal stem and midcranial sulcus as its components. The bifurcated arms, on the other hand, may be called in Leptocorisa varicornis as 'Frontal sutures'. These arms prove true to all the tests of frontal sutures. Further more their function as the lateral limits of the frons is confirmed from the fact that they do not allow fibres of the accessory dilators of the sucking pump and the dilators of the pharynx to go beyond the frontal sclerite. On these grounds the present writer in case of L.varicornis is not prepared to doubt the presence of frontal sutures as indicated by Snodgrass (1947) in insect cranium.

The occipital suture(Figs.1 and 2; ocs).— The progmathous condition has brought about a change in the course of different sutures. The proximal portion of the facial surface is demarcated

from its distal portion by the presence of a transverse suture running slightly posterior both to the ocelli and the compound eyes. Since it does not extend towards the posterior part of the mandibular plate, it is doubtful to say anything about its true nature. However, it should not be confused with "postfrontal suture" as it does not take up the usual course chalked out for it. It also cannot claim to be a complete occipital suture; but its position and course at the same time cannot be ignored. Hence it would be convenient to regard it as incomplete and obsolete occipital suture rather than 'postfrontal sutures'. Internally the occipital suture forms a strong ridge (Figs.16 and 24; ocr) which demarcates the occiput (Figs.1, 2, 16 and 24; Oc) from the distal facial area. Mesally from the occipital ridge hang down two large flat apodemes (Figs.1, 16 and 24; OcAp) which provide attachment to certain muscles.

Butt (1943) has given a confused account of the occipital suture. According to him "On the lower surface of the head extending back from the antenna is a suture (Ocs), not always distinct, which marks off the gula plate (Gu)". In prognathous condition the occipital suture does not demarcate gula from the gena. It is only the forwardly extended postoccipital sutures (gular sutures) in continuation with the hypostomal sutures that separate the genal plate from the gular plate.

The postoccipital suture (Figs.1, 2, 3 and 4; poc).— The postoccipital suture is a sub-marginal suture running parallel to

the dorso-lateral margin of the formen magnum. Internally it forms a ridge called 'postoccipital ridge' (Figs.16, 24, 27 and 28 por). The two ends of the semicircular postoccipital suture turn forward and extend upto the respective posterior tentorial pits (Figs.2, 3, 27 and 28; pt) which are the origins of the hypostomal sutures. Such extensions of the postoccipital suture run parallel to each other and function as the lateral limitations to the proximal portion of the ventral surface of the head capsule and may be termed as "gular suture" (Figs.2, 3, 27 and 28; Gus). The area thus limited by gular sutures, starting from the ventral margin of the foramen magnum and extending near the paired posterior tentorial pits, becomes the 'gula'(Figs.2 and 3 Gu).

The sub-genal and epistomal sutures(Figs.1, 2, 3, 23, 24, 27 and 28).— The forwardly directed head alters the course of the sub-genal suture. This suture starts from the posterior tentorial pits of one side and running in postero-anterior direction passes beneath (ventral) the compound eye to reach the proximal part of the mandibular plate. Thence it turns upwards to demarcate the antennal socket from the proximal portion of the mandibular plate. It is, later on, connected with the opposite member of the other side by a groove which arches over the apical portion of the facial area and is called 'epistomal suture' (Fig.1; es). Internally the epistomal suture develops a strong ridge (Figs.23 and 24; er) and forms a line of demarcation between the clypeus and the frons.

The sub-genal suture can be differentiated into two parts, viz. the hypostomal (Figs.2, 3, 27 and 28; hs) and the pleurostomal sutures (Figs.1, 2, 3 and 24; ps). The former is that portion of the sub-genal suture which extends between the posterior tentorial pits and the base of the mandibular plate. The pleurostomal suture is the connecting portion of the sub-genal suture between the hypostomal and epistomal sutures and passes well above the base of the mandibular plate.

The ocular suture (Figs.1, 2 and 3; os).— The ocular suture is a grooved suture which encircles the compound eye. Internally it forms a distinct ridge (Figs.16, 24, 27 and 28; or) and demarcates a circular ocular sclerite (Figs.1, 2, 3, 16, 24, 27 and 28; OSc).

The antennal suture (Figs.1 and 2; as).— The antennal suture is in the form of a well developed external groove which internally forms a sub-marginal ridge (Figs.16, 23 and 24; ar).

(iii) Areas of the head capsule.—

The different sutures referred to above define different sclerites of the cranium. The following regions are distinct.

The frons (Figs.1 and 2; Fr).— The frons is a triangular plate lying between the clypeus and the occiput. It is bounded anteriorly by the epistomal and laterally by the frontal sutures. Distally the frontal plate carries a short mid-longitudinal

groove (Fig.1; mcs) which internally forms an inflection(Figs.16 and 24; mci).

The clypeus (Figs.1 and 2; Clp).— The epistomal suture separates the frons from the clypeus which appears externally as a pear-shaped sclerite. It has been differently named by various insect morphologists. Myers (1929), Hamilton (1931), MacGill(1947) and Quadri (1950) termed it as clypeus, Putt (1943) recognised it as anteclypeus while Muir (1926) regarded it as clypeo-labrum. The clypeus is bounded laterally by deep folds which separate it from the mandibular plates while the epistomal suture forms its posterior boundary. The clypeus bends downwards to reach the basal portion of the labrum (Figs.2 and 5; Lm) on the under surface of the cranium. It remains undivided into anteclypeus and postclypeus since there does not exist any distinct line of demarcation between the two.

Spooner (1938) regards that in Heteroptera the frons and the clypeus are always in a fused state. Putt (1943) supports Spooner's view and considers the anteclypeus as a distinct region. The present writer does not agree with them due to the presence of a distinct epistomal suture. It could have been taken as a suture dividing clypeus into ante - and postclypeus provided it does not function as a connecting link between the two pleurostomal sutures. As such, considers clypeus and the frons as two separate sclerotic regions of the cranium rather than a composite

structure as mentioned by Spooner. The clypeus is entire and not divisible into ante - and postclypeal regions.

DuPorte (1946) considers "the known inconsistency of muscle origin throws doubt on their value in determining the homologies of the facial sclerites". Snodgrass (1947) says "the facial muscles of the insect head are reliable criteria for determining the homologies of the surface parts of the cranium". As such Snodgrass maintains that the muscles of the sucking pump always arise from the clypeus, the pharyngeal muscles from the frons and one can be differentiated from the other by the presence of the frontal ganglion and its brain connectives. In Leptocorisa varicornis the epistomal suture demarcates the clypeus from the frons. Further evidence is deduced from the origin of the dilator muscles of the sucking pump and the pharynx. The principal dilators of the sucking pump (Fig.35; No.18) is confined to the clypeus and its fibres never go beyond the epistomal ridge. The dilators of the pharynx (Fig.34; No.20) on the other hand, originate from the frons and the frontal ganglion lies anterior to them. The accessory dilators of the sucking pump (Fig.34; No.19) have made access to the distal part of the frons. Snodgrass' (1947) view regarding the myology as the final word for determining the various facial sclerite has been upheld by the present writer in Leptocorisa varicornis by advancing his observations on the principal dilators of the sucking pump and the dilators of the pharynx.

The parietals.— The parietals are the lateral areas of the cranium which are separated above by the stem of the ecdysial suture. Truely speaking such a definition does not give a clue to the correct position of these areas in the insect under review. This area is limited dorsally by the frontal and occipital sutures while the sub-genal and a part of occipital sutures form its ventral limits. The lateral ocelli, compound eyes and the antennae are located on the corresponding parietals. As has been mentioned previously, a narrow band encircling the compound eye within the ocular suture is the ocular sclerite (Figs.1, 2, 3, 16, 24, 27 and 28; OSc) and the rim of the antennal socket enclosed by the antennal suture is the antennal sclerite(Figs.1, 2, 16 and 23; ASc).

The occiput (Figs.1, 2, 16 and 24; Oc).— The occiput is a fairly large sclerite bounded anteriorly by the occipital and posteriorly by the postoccipital sutures.

The postocciput (Figs.1, 2, 3, 4, 16, 24, 27 and 28;Poc).— It is fairly broad dorsally and gradually tapers towards the latero-ventral margin. It surrounds dorso-laterally the foramen magnum. In its lower limit protrude on either side a small process, the 'postoccipital process'(Fig.4; pocpr). The ventral margin of the postoccipital process rests over the knob of the cervical sclerite.

The sub-genal areas (Figs.2, 3, 27 and 28).— The hypostomal as well as the gular sutures work as lateral boundary for

the ventral area of the cranium. The proximal area demarcated by the gular suture is the 'Gula' (Figs.2 and 3; Gu), while the distal area separated by the hypostomal suture is termed as 'Hypostoma' (Fig.3; Hs). The posterior tentorial pits form their limits; the former lies proximal to them while the latter occupies the distal portion of the cranium. The hypostomal and the gular areas of the corresponding sides are completely fused with one another and form large median plates. The gula extends as far distally from the foramen magnum as the posterior tentorial pits while the hypostoma is drawn as far anteriorly from the posterior tentorial pits as the anterior margin of the ventral wall. Distally the hypostoma is fused with the maxillary plate and forms a latero-ventrally placed hypostomal-cum-maxillary plate (Fig.3; Mx + Hs) but mesally, as will be shown later, the hypostoma is represented as an independent sclerite. The pleurostomal suture borders the mandibular plate which is distinguished as 'pleurostoma' (Figs.1, 2, 16, 23 and 24; Mdpl) for reason given in connection with the "Mandibular plates".

The labrum (Figs. 2 and 5; Lm).— The slender tapering lobe-like labrum is suspended from the clypeus by the intervention of a membrane. It has been termed as 'Labrum-epipharynx' by Myers (1928) and Evans (1937) while Hamilton (1931), Butt (1943), MacGill (1947) and Quadri (1949) label it as labrum. The labrum is thinly chitinized, broad at the base and tapering out gradually in postero-anterior direction into a free pointed tip. It extends upto the proximal portion of the second labial segment

with its entire ventral surface transformed with a continuous mid-longitudinal concavity (Fig.5; mlcLm). This enables the labrum to become a perfect dorsal cover of the basal portion of the labial groove. The proximal end of the labral margin forms an inward bend and thus gives rise to a basal constriction (Fig.5; bcLm) which keeps the margins of the labral groove pressed against each other so as to close it completely. The bristle bundle after emergence from the head cavity passes into the labral groove (Fig.5; Lmg) and is thus kept in position by the basal constriction when it is in action. The outer surfaces of the mandibular stylets are regular without any ridge and the flange in the labral groove is wanting. The bristle bundle therefore glides smoothly within the labral groove. The flange and ridge in the labral groove and the outer upper surfaces of the mandibular stylets respectively, as claimed by Butt (1943) in Notonecta, are absent. The structure of the labral groove and the outer surfaces of the mandibular stylets of L.varicornis correspond to that of Oncopeltus and Magicicada described by Butt (1943) and figured by Snodgrass (1944) respectively. Both the workers do not mention the basal constriction of the labral groove and its "holding mechanism".

The mandibular plate (Figs.1, 2, 16, 23 and 24; Mdpl).— The mandibular plates are the two lateral lobes of the head, each lying on either side of the clypeus. It has been variously termed by different workers. Myers (1928), Hamilton (1931), Butt(1943) and Snodgrass (1944) termed it as lorum, while Weber (1933) called

it as mandibular plate.

Myers (1929) and Weber (1933) regard the mandibular plates as a part of the genae. In Lentocorisa varicornis, the present writer has described the presence of distinct hypostomal and pleurostomal sutures as well as the areas they define. It is obvious, therefore, that the mandibular plates cannot be mere extensions of the genae. Evans (1937), Spooner (1938), and Ferris (1943) consider the mandibular plate as the lateral extensions of the postclypeus. The presence of a groove between the mandibular plate and the clypeus proves that the former is an independent completely separate sclerite and not the lateral extensions of the clypeus. Bearing in mind these facts it can be said without any shadow of doubt that the mandibular plates instead of being the extensions of some other region of the cranium are independent sub-genal sclerites and can be considered analogous to the pleurostomal areas of the generalized insects. Thus the present writer confirms Quadri's (1950) view regarding the mandibular plates in Pyrilla.

Along the inner margin of the mandibular plates are situated, on either side of the clypeus, flat vertical plates termed as 'lora' (Figs.16, 23, 24, 30: Lo). They extend dorso-laterally from the hypopharynx. The present writer upholds the view of Quadri (1950) who rejects the universely accepted old view to consider lora and mandibular plates as synonyms and

suggests to regard them as different structures in the insect cranium.

The maxillary plate (Figs.2, 3, 27, 28, 31, 33 and 34;Mxpl).— The maxillary plates form the latero-ventral region of the distal part of the cranium. The presence of a well developed gula brings about a change in the position of the maxillary plates. These, unlike homopterous insects, get forwardly extended to assume a ventro-lateral position in relation to the compound eyes instead of being sub-genal. Further their position in relation to the mandibular plates is also affected with the result that the former becomes latero-posterior rather than dorso-anterior as shown in homopterous cranium. Each maxillary plate is a wide flat plate with anterior area slightly narrow. It develops a small conical process (Figs.3, 27, 28, 31, 33 and 34; Mxpr) from its inner anterior margin. The present writer retains the term "maxillary process" given by MacGill (1947) since it appears more appropriate and correct than the 'maxillary apodeme' which is suggested by Hamilton (1931) in Nepa. The maxillary as well as the mandibular stylets converge to pass between the two maxillary processes. The maxillary plate is demarcated from the mandibular plate by a deep maxillary fold. On the other hand, ventrally it is merged into the hypostoma and its actual ventral limitation is difficult to define. This area, therefore, can be conveniently called the "maxillary-cum-hypostoma (Fig.3; Mx + Hs). The anterior margin of this plate forms a deep cup-shaped emargination.

Running along either sides of the emargination and directed postero-mesally is a line of demarcation between the maxillary plate and the hypostoma. The lines of the corresponding sides do not meet each other but end apart leaving a proximal narrow area. These lines thus split up the maxillary-cum-hypostomal area into two lateral maxillary (Fig.3; Mxpl) and antero-central portion, the hypostoma. As such the emarginated portion of the anterior margin which is limited by these lines becomes the anterior margin of the hypostoma while the remaining portions become the anterior margins of the maxillary plates. The space formed by the invagination of the margin contains the basal portion of the labium and provides membranous susnension to the latter with the anterior margin of the hypostoma. This can be considered to correspond to the "Oral fossa" of stenobracon deesae described by Alam (1951). All along the two lines of demarcation between the maxillary plates and the hypostoma, hang downwards two small triangular plates, the bucculae (Figs.2 and 3; Buc). The present writer considers them to owe origin from the corresponding maxillary plates. Each buccula lies on either side of the oral fossa. These form lateral covers for the proximal part of the basal segment of the labium. Towards the posterior end of the maxillary plate is attached internally a small sclerotized narrow curved piece, the maxillary lever (Figs.27, 28 and 34; Mxlvr) which has made connection with the inner margin of the maxillary stylets as well.

(iv) The tentorium.—

The structure of the tentorium in Hemiptera has caused much confusion among the previous workers such as Awati (1914), Muir (1926), Myers (1928) and Hamilton (1931). Muir(1926) in Cicada recognized the strongly chitinized trough supporting the sucking pump as the anterior arm of the tentorium. He regarded it as arising from the frontal suture and homologized the trough with the frontal plate of Orthoptera. He (1929) changed this view by reviewing his own work in Cicada (1926) and assumed the anterior arm of the tentorium as arising from the hypopharynx and not from the anterior portion of the head capsule. Myers(1928) held Muir's view and named the anterior arms as the dorsal arm. He observed a pair of pits on the frontal suture and recognized them as frontal pits. Hamilton (1931) claimed the presence of only the anterior arm of the tentorium. She followed Muir and considered the chitinized trough as the anterior arm of the tentorium but was of the opinion that the arms do not arise from the frontal suture but between the sides of the clypeus and the paired lora. Putt (1943) in Heteroptera considers that the tentorium is entirely wanting. The presence of the well developed tentorium has been shown in Homoptera by Putt (1943) and Quadri (1949-50). Neverthe-less, the present writer is not prepared to accept the total absence of the tentorium as suggested by Putt (1943) in Heteroptera.

In Lentocorisa varicornis, the posterior arms of the tentorium (Fig.2; PAT) are quite clear. These start as well chitinized rods from the paired distinct posterior tentorial pits (Figs.2 and 3; pt) and take up an antero-mesal directed course to unite with the occipital apodemes. This union of the curved posterior tentorial arms with the occipital apodemes makes the former a functionally stable region for the origin of antennal levator muscle (No.1b) and retractor muscle (No.13b) of the mandibular stylet. Except these arms neither the tentorial body nor its other arms are present.

(v) Antennae with their muscles.—

The Antennae (Figs.6-16).— The filiform antennae are five segmented (Fig.6). They are located on the anterior part of the parietals and occupy a dorso-lateral position. Each antenna arises from the side of the head capsule anterior to the compound eye and posterior to the base of the mandibular plate of its side. It consists of two main parts viz., the basal shaft (Fig.6; bs_1) and the flagellum (Fig.6; fl). The former is four jointed.

The proximal segment or the first antennal joint is termed as scape (Fig.6; Scp). It is the largest of all the antennal segments and is yellow with slight tinge of brown. The basal rim of the scape (Fig.7; ar) is lodged in the antennal socket (Fig.7; an). The latter possesses an articular knob called

"Antennafer" (Fig.7; af) which articulates with the concavity of the rim (Figs.7 and 13; Con) in its dorso-lateral portion. On each of the dorsal (Figs.6, 13 and 16; Ap_1) and ventral (Figs.6, 13 and 16; Ap_2) margins of the basal rim is attached a strong and broad apodeme which gives insertion to the extrensic muscles of the antenna. The distal wall of the scape forms ventrally a deep emargination (Figs.9 and 15; vmScp) while the dorsal margin (Figs.8 and 14; dmScp) is almost straight. On either side of its lateral walls arise an articular knob(Figs.8, 9, 14 and 15; Ark) which provides articulation to the proximal end of the second antennal joint. The scape,as will be described later, gives attachment to the intrinsic muscles as well. It is also supplied with tracheae and nerve fibres.

The second antennal segment designated as "pedicel" (Fig.6; Pe) is shorter than the first. It is dark brown with its base deep yellow with a tint of red. It is slightly broader at the base and narrower at the distal end. The proximal wall of the pedicel forms two articular knobs (Figs.8, 9, 14 and 15;Ark_1) on its lateral sides and has a dicondylic articulation with the distal end of the scape. A membrane intervenes between the two joints. The distal end,on the other hand,has a concavity(Fig.10) into which is placed the convex proximal end of the third joint. Minute hairy growth is present all round the surface of pedicel.

The third antennal joint like that of the second is short, dark brown with its base deep yellow with red tint. It is

almost uniform in thickness throughout its length. It forms a convexity (Fig.10) in its basal region which fits closely into the distal concavity of the pedicel. The articulation between the two becomes more firm by the presence of a thin membrane. The distal wall of this joint forms a concavity (Fig.11) for the articulation of the fourth segment.

The fourth antennal joint also known as 'ring-joint' (Figs.6, 11 and 12; rg) is the smallest segment of the antenna. It is more or less cup-shaped in structure and dark brown in colour. The convexity (Figs.11 and 12) in its proximal end is more pronounced than that of the third joint and its articulation to the latter corresponds to that described in the previous one. Distally it forms a deep concavity into which articulates the base of the flagellum. The fine hair-like processes are present on the wall of this joint also.

The flagellum (Fig.6; fl) is the anterior most part of the antenna. It is longer than other antennal segments except the first. It is also dark brown with its base deep yellow with red tint. It tapers both anteriorly and posteriorly to blunt ends, the tapering at the proximal end (Fig.12) being more abrupt than that of the distal one. The proximal end of the flagellum fits into the articular concavity of the ring-joint, while distally it is free. The hair-like processes in this region are more fine and attain a dense growth throughout the joint.

The antennal muscles (Figs.13, 14, 15 and 16).— These consist of two types of muscles viz. the extrinsic and intrinsic. Among the former are met with one levator and two depressor muscles, while in the latter two sets of muscles namely the levator and depressor of the flagellum are present.

(a) Extrinsic muscles :-

(1) The levator muscle of the antenna (Figs.13 and 16; No.1).— It is a large muscle consisting of two closely applied bundles having almost common points of origin and insertion. One of the bundles (No.1a) arises from the lower margin of the occipital ridge a little on the lateral side of the flat base of the occipital apodeme, while the other bundle (No.1b) originates very close to the previous one on the basal portion of the apodeme. Both the bundles take up a convergent course to end combiningly on the flat apodeme present on the outer dorso-lateral region of the scapes' margin. Their common points of origin and insertion make it clear that these two bundles are parts of the same muscle. The increased surface for their origin, and the firm attachment ensures a powerful action. They work conjointly and their contraction elevates the antenna.

(2) The first depressor muscle (Figs.13 and 16;No.2).— It is a large muscle and originates from the distal surface of the occipital apodeme. Running in ventro-lateral direction the fibres converge to end on the flat apodeme developed by the ventro-mesal area of the scapes' base.

(3) The second depressor muscle(Figs.13 and 16;No.3).— It is a stout flat muscle arising from the distal portion of the mid-cranial ridge. It runs latero-ventrally along the dorsal wall of the head capsule and gets inserted on the inner side of the same apodeme on which the first depressor is attached.

(b) Intrinsic muscles :-

(1) The levator of the flagellum (Fig.14; No.4).— It is a pinnate muscle and arises from the inner margin of the dorsal wall of the scape. Its fibres are attached on a tendon(Figs.8 and 14; ap_1) which ends on the dorsal half of the proximal rim of the pedicel.

(2) The depressor of the flagellum(Fig.15; No.5).— It is also a pinnate muscle and originates from the inner margin of the ventral wall of the scape. Its fibres are inserted on an apodeme (Figs.9 and 15; ap_2) which ends on the ventral half of the proximal rim of the pedicel.

There are no muscles in the pedicel and the flagellum, only the nerve fibres and the tranchae are present.

(vi) The mouth parts.—

The mouth parts of Leptocorisa varicornis, Fabr. are classified among those of the piercing and sucking type. The long, rigid and segmented labium enclosing the highly modified paired long and slender mandibular and maxillary stylets together with the hypopharynx enclosing the salivary syringe constitute

the main organs of ingestion.

The labium (Figs.2 and 17-20; Lb).— The four segmented long and slender labium or rostrum arises on the ventral side of the head capsule. When not in use it is kept curved mesally on the ventral side of the head and thorax with its tip reaching the mesocoxae.

The first or the proximal most segment (Figs.17, 18 and 20; Lb_1) is the longest joint of the labium. Its proximal end brings about the suspension of the labium by a thin membrane from the oral fossa and is overlapped laterally by the bucculae. The distal portion of this segment articulates with the second labial segment. A small sclerotized plate (Figs.18 and 20; vLbS) is attached on its latero-ventral wall. The dorsal surface of the proximal segment carries a shallow groove termed as labial groove (Figs.17 and 19; Lbgr). A sclerotized labial plate(Figs.17, 19 and 20; Lbpl) is placed within this groove. The labial plate is produced proximally into a broad chitinized apodeme(Figs.17 and 20; LbAp) which corresponds to the 'free sclerotized rod' of cicada and 'labial apodeme' of Pyrilla perpusilla described by Myers (1928) and Quadri (1950) respectively. Anteriorly, the labial plate becomes membranous in the middle and sclerotized along the margins of the labial groove.

The second and third labial segments are almost similar in structure to that of the proximal segment except that the

chitinized apodeme is absent. The sclerotized margins of the membranous labial plate are more or less pressed against each other so as to form a close tube into which is enclosed the bristle bundle.

The proximal portion of the fourth or the apical segment of the labium resembles with the second and third labial joints, while distally it has undergone certain modifications for holding the stylets in position when they are in action.

The previous workers did not pay much attention on the structure of the apical segment. Bugnion and Popoff (1911) consider it to be closed at the tip, while Myers (1928) regards that the apical portion of the labial segment is not closed. Leon (1901) and Hamilton (1931) described it to possess dorsally a pair of hairy labial appendages. Recently Quadri (1949-51) has entered into details of the structure of the apical segment and has shown the presence of sclerotized processes which form a ring to enclose the stylets and hold them when they are penetrating deep into the tissue of the food plant.

In Leptocorisa varicornis, the dorsal and the ventral walls of the distal end are deeply emarginated and laterally form a pair of apical lobes (Fig.19; aplLb) which are provided with sensory hairs. The labial plate runs upto the anterior margin and then becomes bifurcated into two arms each of which gets completely fused with the corresponding crescent-shaped sclerotized processes (Fig.19; SprLbpl). On the other hand, the

processes of either sides become united to form an 'X' shaped chitinous plate which lies between the apical lobes and gives support to the stylet from below. From the dorso-lateral wall of each apical lobe arises small mesal sclerotized process (Fig.19; mprdlw) which corresponds to the "labial clamp" of Idiocerus sp. (Quadri 1949). The muscle acting upon the labial plate protract it as a result of which the mesal processes of the corresponding sides come closer and closer to form a narrow arch. Thus the mesal processes in co-ordination with the chitinous plate form a ring which holds the styletsin position when they are penetrating the plant tissue.

Muscles of the labium (Fig.20; Nos.6-12).— The three sets of muscles met with in the labium are the protractor, the retractor and the transverse muscles. The muscles present in each of the four labial segments are as follows :-

(1) Extrinsic muscle.— There is only one extrinsic muscle present in the labium.

The hypopharyngeal retractor of the labium (Fig.20;No.6).- It is a long and thin muscle and originates from the lower (inner) wall of the ventral hypopharyngeal processes. It runs in anterior direction to get attached on the sclerotic piece between the first and second segments. The extension of this muscle drags the second labial segment and thereby helps in the increase of the labial curvature during feeding. This is similar to adductor

No.1 of Oncopeltus and differs in origin from the adductor No.2 of Cimex.

(2) Intrinsic muscles.— The following intrinsic muscles are met with.

(i) The first retractor muscle(Fig.20; No.7).— It originates posteriorly from the proximal end of the first segment and occupies a dorsal position in relation to the hypopharyngeal retractor of the labium. It runs in anterior direction and is attached at the proximal rim of the second labial segment. This corresponds to the 'first abductor' muscle of Oncopeltus and Cimex.

(ii) The second retractor muscle(Fig.20; No.8).— It is of long and slender muscle originating posteriorly from the proximal end of the third segment. It runs laterally in anterior direction and are inserted on the proximal rim of the apical segment. It resembles the retractor muscle of Oncopeltus and adductor No.6 of Cimex.

(iii) The first protractor of labial plate(Fig.20;No.9).— It originates from the distal portion of the basal segment and runs obliquely to get inserted on the ventral wall of the labial apodeme. It is similar to the second adductor of Oncopeltus and first adductor of Cimex.

(iv) The second protractor of labial plate(Fig.20;No.10).— The second segment is provided with only one group of protractor

muscle, which like the first protractor arises ventrally from the ridge between the second and third segments. It spreads over a large part of the labial plate and runs in antero-ventral direction. It is attached on the ventral wall of the labial plate. This muscle resembles the third adductor of Oncopeltus and fifth adductor of Cimex.

(v) The first set of transverse muscles of the labial plate (Fig.20; No.11).— These are divided into three separate bundles of muscle fibres. The bundles on the proximal (No.11a) and distal (No.11c) regions of the third labial segment are almost equal in size. They are smaller than the median (No.11b) which is broader and occupies a large portion of the segment. These muscles arise from the ventral surface of the labial segment and get inserted on the mid-ventral wall of the labial plate. These bundles are similar to transverse Nos.1, 1a and 2 of Oncopeltus. Kemper (1932) has shown the presence of transverse 1 and 2 only in Cimex.

(vi) The second set of transverse muscles of the labial plate (Fig.20; No.12).— The fourth (apical) segment is provided with only transverse muscle which are identical in the manner of their origin and insertion to that of the preceding segment. Their action on the labial plate is probably responsible for clasping the maxillary and mandibular stylets when they are in action of penetration. This bundle corresponds to transverse muscle No.3 of Oncopeltus and Cimex.

The mandibular stylets (Figs.21, 23, 24 and 34; MdS).— Each mandibular stylet arises from the walls of the invaginated bristle pouch (Fig.34; bp) which is formed from the ventral wall of the head capsule between the inner surface of the maxillary plate and the outer surface of the ventral wings of the hypopharynx.

The paired mandibular stylets are long, slender and sclerotized structures. These lie on the outer side of the bristle pouch and their bases lying a little posterior to the proximal end of the lorum and are far back to the bases of the maxillary stylets. The mandibular stylets after converging in meso-anterior direction pass below the lora but mesal to the mandibular plates to reach the maxillary processes. Their convergent nature enables them to come closer and closer to the paired maxillary stylets till the labial base is reached where they get applied on the outer surface of the maxillary stylets. The inner side of the mandibular stylet is slightly concave which rests against the outer convex surface of the maxillary stylets. The inner surface of the dorso-lateral region of the mandibular stylet develops a distinct groove which provides articulation to the corresponding ridge present on the outer surface of the maxillary stylet in their dorso-lateral region.

The mandibular stylet at the proximal end is thickened into a broad base while distally it tapers to a blunt apex. At the base of the stylet is a more or less globular sac, known as

the mandibular sac (Figs.21, 23, 24 and 34; Mds). The sclerotized inner and outer margins of the sac give rise to two arms of the stylets. From the outer margin of the mandibular sac arises an elongated arm (Figs.21, 23, 24; Mda_1) which extends deep into the cavity of the head running along the lateral wall of the head capsule, while the inner margin gives rise to a small sclerotized rod-like arm (Figs.21, 23 and 34; Mda_2) running almost parallel to the inner side of the mandibular stylet. Anteriorly it becomes feebly chitinized having a tendon-like (Figs.21, 23, 24 and 34; Mdtn) appearance. To this tendon is attached the inner end of the triangular mandibular lever (Figs.21, 23, 24 and 34; Mdlvr). The latter is a sclerotized plate whose outer end is connected with the cranium at the junction of the pleurostomal and epistomal ridges. The tip of the mandibular stylet (Fig.22) is curved with serrated outer surface.

Butt (1943) considers the sclerolized rod-like arm and the mandibular lever as the mandibular lever and mandibular process respectively. Awati (1914) and Weiswander (1926) in Lygus and Banatra respectively consider the tendon as a chitinized membrance which connects the lever with the stylet. Awati (1914) and Hamilton (1931) have shown the attachment of the lever with the genal suture; Butt (1943) regards that its connection is always just mesad and infront of the antennal fossa; Quadri (1950), on the other hand, has described its attachment on the epistomal suture.

The mandibular muscles.— These consists of two sets of muscles namely the retractor and protractor muscles.

(i) The retractor muscles (Fig.24; No.13).— There is a pair of retractor muscles having different points of origin. One bundle (No.13a) arises from the dorso-lateral portion of the postoccipital ridge and is inserted on the outer arm of the mandibular base. It is a long and stout muscle with convergent fibres in antero-mesal direction to end on the outer arm of the stylet's base. The other bundle (No.13b) originates from the distal part of the flat occipital apodeme. It runs in a forward direction to get inserted on the mandibular sac. These muscles correspond to retractor muscles of the mandible described by MacGill (1947) and Quadri (1949). The origin and insertion of the bundle No.13a, is similar to that of the Notonecta(Butt 1943) while the origin of the second bundle (No.13b) corresponds to that of the Pyrilla (Quadri 1950). But neither of the two workers have shown the presence of both the bundles in these insects.

(ii) The protractor muscle (Fig.24; No.14).— It is a stout bundle of muscle fibres originating from the inner surface of the lorum and running postero-mesally is inserted on the broad base of the mandibular lever. The protractor muscle unlike that of the retractors are not attached directly on the mandibular stylet. Myers (1929) described them originating from the lora which corresponds to the mandibular plates of L.varicornis. The origin and insertion of the protractor muscle in similar

to that of Pyrilla (Quadri 1950). Butt (1943) in Oncopeltus named it as the"hypopharyngeal-mandibular muscle". MacGill(1947) in Dysdercus described the protractor muscle as originating from the dorsal wall of the head-cavity external to the dilator muscle of the sucking pump. Hamilton (1931) named them as antogonistic muscles attached to the mandibular muscle and inserted into the head capsule. Butt (1943) in Acrosternum has shown another set of muscle arising in the anterior extremity of the jugum (mandibular plate of L.varicornis) and inserting on the outer half of the lever. In the L.varicornis, the writer could not find any such division of the protractor muscle.

The maxillary stylets(Figs.25, 27, 29 and 34; MxS).— Each maxillary stylet like the mandibular stylet arises from the walls of the bristle pouch (Fig.34; bp) lying on the inner side of the latter. Their bases extend far posteriorly to those of the mandibular bases.

The maxillary stylets are a pair of long and slender sclerotized rods somewhat longer and thinner than the mandibular stylets. They run along the inner side of the corresponding maxillary plate and after coming out of the bristle pouch, they extend along the sides of the hypopharynx. As the two stylets enter into the labial groove in the region of the maxillary processes, they get attached to each other. In this compact manner they run throughout the length of the labial groove. The

maxillary stylets are broader at the base and taper towards the distal end. The broad base of the maxillary stylet which is postero-lateral to that of mandibular stylet forms a pouch known as the maxillary sac. The ventral wings of the hypopharynx support the inner vertical wall of the maxillary sac (Figs.25, 27, 28 and 34; Mxs). Unlike the mandibular stylets, the maxillary stylet is not bifid at the base. A sclerotized strip called the maxillary lever (Figs. 25, 27, 28 and 34; Mxlvr) is joined with the inner side of the stylet in the region of its sac. The outer end of the lever is attached to the head wall in its hypostoma-cum-maxillary plate region. The attachment of the maxillary lever with the head wall becomes more firm by the support of the fibres (Figs. 25 and 27; f_1) arising from the maxillary sac to the epidermal layer of the body wall. As pointed out by Butt(1943) these fibres probably correspond to "tonofibrillae". Another series of fibres (Figs. 25, 27, 28; f_2) along the hypopharyngeal wing connect the maxillary lever with the head wall.

The inner surface of each maxillary stylet develops a mid-longitudinal ridge (Fig.29) which divides it into an upper and a lower continuous grooves. The groove in union with the corresponding grooves of the second maxillary stylet form an upper complete canal called "Suction canal" (Fig.29; sc) and a lower called "Ejection canal" (Fig.29; ec). The mid-longitudinal ridge of one develops alternating teeth and furrows which fit into similar structures of the second so as to give a perfect

interlocking mechanism to the maxillary stylets. The two canals are sub-equal in size, the ejection canal is less wider. The tips of the maxillary stylets (Fig.26) are sharply flattened and non-serrated. MacGill (1947) describes the tip of maxillary stylets as serrated.

The maxillary muscles.— There are two sets of muscles attached to the maxillary stylets.

(i) The retractor muscle (Fig.23; No.15).— It originates posteriorly from the postoccipital ridge almost lateral to the mandibular retractors and is inserted on the posterior area of the broad base of the maxillary stylet. It runs below the retractor of the mandibular stylets and is more or less uniform throughout its course. This muscle corresponds to the retractor muscle of maxillary stylet described by Hamilton (1931), Putt (1943), MacGill (1947) and Quadri (1950) in Nepa, Oncopeltus etc., Dysdercus and Pyrilla respectively.

(ii) The protractor muscle (Fig.23; No.16).— It is a stout muscle consisting of three bundles. One of these (No.16a) starts from the antero-lateral margin of the maxillary plate and is inserted on the lateral area of the maxillary stylet. The second (No.16b) arises from the anterior margin of the maxillary plate near the maxillary processes and is attached on the under-surface of the stylet's base. The third or the innermost bundle (No.16c) originates from the wall of the bristle pouch and is inserted on the inner (anterior) edge of the stylet's base.

Butt (1943) has recognised three bundles of protractor muscle with details on their points of origin but did not give similar account of their insertion. Awati (1914) and Hamilton (1901) have shown one "lever muscle" lying between the mandibular and maxillary levers, but no such muscle is present in L.varicornis.

The hypopharynx (Figs.30, 31, 33 and 34).— It has undergone modifications from the generalized insects. It is a sclerotized pad-like structure and consists of an elongated, cylindrical central mass (Figs.30, 31, 33 and 34; m^{n}phyl) which tapers anteriorly to form a narrow tube. The latter has membranous suspension from the maxillary process. Posteriorly the central mass is fused with the salivary syringe. The hypopharynx carries three processes, two of them are paired while the third is unpaired.

(i) Paired latero-dorsal processes (Fig.30; dlpr^{n}phy,lo).— They arise from the dorsal surface of the central mass of the hypopharynx, and run in dorso-lateral direction to end on the dorsal area of the respective mandibular plates. These are termed as "Lora" by Quadri (1950). These vertical processes together with the median lobe of the hypopharynx give support to the sucking pump. Myers (1928) considers the dorso-lateral plates of hypopharynx to be directly continuous with the lora.

(ii) Paired ventral processes (Figs.30, 31, 33, and 34; vpr^{n}phy).— These are a pair of strap-shaped flat plates which have been produced posteriorly as two wings. These

arise laterally from the central mass of the hypopharynx and extend posteriorly towards the foramen magnum. These processes run almost parallel to each other as sclerotized flat plates upto the maxillary lever and then expand. Near the maxillary lever the ventral processes become feebly sclerotized and bent abruptly towards the lateral wall of the head thereby assuming the shape of a sickle. The posterior tips of the corresponding processes lie far apart from each other. The lateral surface of the distal portion of these processes has membranous connections with the basal parts of the maxillary stylets. The present writer considers these connections to function as suspensoria for the maxillary stylets. Hamilton (1931) regards them as membranous sling. The ventral processes of the hypopharynx have been called as "Posterior tentorial arm" by Buginon and Popoff (1911) and Awati (1914) in Graphosoma and Lygus respectively. Evans (1939) designated them as the hypopharyngeal apophyses.

(iii) Median-dorsal process (Figs.30,31,33 and 34;mdprHphy).— It is a single piece and arises from the ventral wall of the median hypopharyngeal lobe. It runs mesally towards the posterior region of the head as a sclerotized hollow trough. It has a gradual tapering towards anterior and posterior ends while mesally it is comparatively broader. It extends beyond the maxillary lever upto half the distance of the arc-shaped distal portion of the ventral process. The buccal cavity of the alimentary canal

gets support from its dorsal concavity. It has been regarded as "floor of the sucking pump" by Butt (1943) while Snodgrass(1944) termed it as "Sitophore". Muir (1926) and Hamilton (1931) considered it as the 'anterior arm of the tentorium' while Myers (1928) called it 'dorsal arm of the tentorium'.

The salivary syringe (Figs.31,32,33 and 34; Ss).— It is a sclerotized cylindrical cup-shaped structure and lies posterior to the median lobe of the hypopharynx. Each ventral process of the hypopharynx lies on its lateral sides and the median dorsal process occupies a dorsal position. It is broad at the proximal end and gradually tapers to a point in the distal region. The hollow cavity of the syringe is pierced laterally by the common duct of the salivary glands (Fig.32; cSdt). The anterior hollow process of the salivary syringe is produced into a slender, pointed ejaculatory duct (Figs.31,32,33 and 34; edt) which runs through the median lobe of the hypopharynx to terminate at the base of the ejection canal. The proximal chamber as well as the distal hollow process of the salivary syringe is lined internally by an epithelial layer (Fig.32; epthl).

The posterior end of the salivary syringe carries mesally a thick knob-like process known as the piston (Figs.31, 32,33 and 34; pn). It is firmly enclosed within the chamber and is proximally produced into a thin apodeme termed as the handle of the piston (Figs.31-34;hpn). It runs ventrally almost parallel to the median dorsal process of the hypopharynx. At a short

distance posterior to the piston, the handle forms paired lateral conical projections (Figs.31,33 and 34: npn) which probably allows a restricted forward movement to the piston. When seen from the lateral side, the apodeme (handle) appears as a leaf-shaped structure (Fig.32) giving an increased surface for the attachment of the muscles. When in action the salivary syringe pumps the saliva through the ejaculatory duct into the ejection canal of the maxillary stylets.

The muscles of the salivary syringe (Fig.33: No.17).— These are a pair of flat muscles and originate mostly from the underside of the ventral process of the hypopharynx and partly from the ventral portion of the rim of foramen magnum. The fibres of this muscle run in antero-mesal direction and are attached on the handle of the piston. These are of uniform breadth throughout their course and are the chief dilator muscles of the salivary syringe. The muscles regulate the flow of the saliva by alternate contraction and relaxation. Butt (1943) and MacGill (1947) in Onconeltus and Dysdercus respectively have shown the origin of the dilator muscles of the salivary syringe from the posterior wall of the head capsule.

The sucking pump with its muscles.— The sucking pump is an elongated tubular structure lying dorsally within the concavity of the median process of the hypopharynx. It is connected anteriorly with the food maetus while posteriorly it is followed by the pharynx. It is provided with two sets of dilator muscles.

(i) The principal dilator of the sucking pump (Fig.35; No.19).- It is a large bundle with fibres originating from the inner surface of the clypeus. It runs dorso-ventrally and gets inserted on the distal part of the sucking pump. As its fibres do not extend beyond the epistomal ridge and are confined only to the clypeus, it has been designated as the 'Principal dilator' muscle of the sucking pump. This muscle corresponds to the fan-shaped "Divaricator muscle" of Nepa, "first dilator (dlcb)" of Oncopeltus and "dilator of sucking pump" of Pyrilla described by Hamilton (1931), Butt (1943) and Quadri (1950) respectively.

(ii) The accessory dilator of sucking pump (Fig.35; No.19).— It is a smaller than the principal dilator and its fibres originate from the distal part of the frons along the inner side of the frontal sutures. It runs obliquely in ventro-anterior direction to get inserted on the proximal portion of the sucking pump. Some of its fibres extend over the portion of the sucking pump upon which are inserted the fibres of the principal dilator. This muscle is similar to the second dilator ($dlcb_2$) of Oncopeltus described by Butt (1943). The present writer differs from Butt on the region of origin of this muscle for reasons already given while discussing the facial sclerites of the cranium. Dorsally the principal and the accessory muscles for reasons of their course of action are kept apart and the space thus left is traversed by the second depressors of the antenna.

The pharynx with its muscles(Fig.35; Nos.20,21 and 22).—

The true pharynx is an elongated narrow tube lying posterior to the sucking pump. Its anterior and posterior chambers can best be differentiated by the origin and attachment of the muscles. The dilator muscles of the anterior pharynx (No.20) originate on mid-dorsal surface of the head capsule from the inner side of the frontal sutures. These run dorso-ventrally and get inserted on the dorsal wall of the pharynx. The muscles are in the form of small bands of fibres and occupy a considerable large area. Another muscle (No.21) which is strap-shaped arises from the mid-dorsal line of the head capsule between the pharyngeal dilators of either sides. It runs obliquely and gets attached dorsally on the anterior part of the pharynx a little posterior to the accessary dilator muscle of the sucking pump. These muscles are similar to that of the Oncopeltus (Butt 1943). The small thin and strap-shaped dilator muscle of the posterior pharynx (No.22) arises posterior to the nerve connectives from the inner wall of the postero-dorsal surface of the head capsule. It gets inserted on the posterior part of the pharynx.

(vii) The piercing and feeding mechanism.—

A great deal of controversy exists upon the mode of feeding in Hemiptera as a result of which two schools of thought have come into existence. All insect morphologists have accepted Weber's (1928, 30) view as unquestionally a recognized fact on the mode of feeding in Hemiptera. Recently Quadri (1949) has entirely changed the old concepts of piercing mechanism.

He has confirmed his earlier findings in Pyrilla (1950) and other aquatic bugs (1951). According to old theory it is the mandibular stylets which are the chief piercing organs, while the new theory holds that the maxillary stylets are solely responsible for the act of piercing the tissue of the substratum. Upon the basis of the following reasons the writer believes that in Lentocorisa varicornis the new theory of Quadri is more reasonable and practical than the old one.

(i) In insects which were killed in picro-chlor-acetic fixative, it has been invariably seen that the apices of the maxillary stylets lie far in advance to those of the mandibular stylets. This is also confirmed while studying the transverse sections of the labium where the maxillary stylets make their appearance first.

(ii) The apices of the maxillary stylets are pointed and non-serrated and therefore more suited for the act of piercing the tissues; while the mandibular stylets have blunt apices and their outer surface bears recurved hooks. They seem to be better adapted for anchoring in the wound rather than piercing into the tissue.

(iii) The maxillary stylets are much longer and originate far more posterior to the mandibular stylets.

(iv) The ridges and furrows bring about a firm interlocking mechanism to the maxillary stylets and as such their independent movements as suggested by Weber is impossible and therefore

both the tightly conjointed maxillary stylets work together.

(v) The maxillary stylets are provided with three protractor muscles which are directly inserted on its base, while the mandibular stylet carries only one protractor muscle having an indirect attachment on the mandibular lever. The protractor muscles of the maxillary stylets are thus more effective and the stylets can traverse a long distance inside the plant tissue.

As has been pointed out in the fore-going pages the labium plays an important part in holding the stylets in position when they are in action. Besides, it has also been shown that the labral basal mechanism functions in keeping the stylets in position and thus saving them from going astray. The maxillary stylets are interlocked with each other and form two canals, the dorsal being the 'suction canal' and ventral the 'ejection canal'. The maxillary stylets penetrate into the substratum while the mandibular stylets simply come in their wake. Later on, on reaching a little distance into the tissue the mandibular stylets anchor it by means of the recurved hooks present on their outer surface. Their anchoring function has also been reported by Snodgrass (1944) and Quadri (1949). The food maetus is a connecting tube or space lying between the suction canal and the sucking pump. It is dorsally roofed over by the basal portion of the labium and the distal part of the clypeus, while ventrally the median dorsal surface of the hypopharynx forms its floor. The food maetus is followed by the sucking pump while

the pharynx comes next to it. The constriction of the sucking pump with the pharynx becomes the true mouth. The ejection canal is in direct communication with the protruded tapering tip of the salivary syringe.

When the maxillary stylets have reached a desired depth and the mandibular stylets have firmly got hold of the tissue, the suction of the liquid food begins. The powerful dilators of the salivary syringe by simultaneous contraction and relaxation bring the piston in a regular motion. The saliva thus pumped through the ejection canal comes in touch with the food within the hosts' tissue. The food is sucked up into the food canal due to the action of the sucking pump which is provided with two groups of strong muscles which contract and relax one after the other in quick succession. The contraction of the first group brings about an increase in space of the sucking pump and the food is drawn up. When the muscles of the first group relax, those of the second contract as a result of which the food is pushed back into the pharynx. The relaxation of the muscles of the second group and the contraction of the pharyngeal dilators forces the food into the oesophagus. This process continues till the insect is full fed.

II. THE THORAX

The thorax of Leptocorisa varicornis is fairly large and occupies about one third area of the body. It is divided into three distinct segments viz. the prothorax, mesothorax and metathorax. Each of the three segments bear one pair of legs. The mesothorax and metathorax also carry paired wings. The head is connected with the thorax by means of a thin membrane which forms the neck or cervix.

The thorax is longer than broad. The division of the thorax into the prothorax and mesothorax is fairly marked off by the presence of an intersegmental area which is traversed by thin intersegmental membrane. Anteriorly the protergum extends over the posterior area of the cranium and thus the latter appears to be telescoped into the former. The protergum forms an arch and extends posteriorly over a part of the mesothorax. Posterior to it, the meso- and metathoracic tergites are almost flat. Dorsally the meso- and metathorax are closely apposed to each other while the lateral and ventral regions have undergone almost complete fusion. The inter-segmental area is highly reduced in the dorsal region with its intersegmental membrane not visible from outside. The scutal region of the mesothorax is fairly large and internally bears certain ridges. It is over-lapped dorsally by the protergal shield while the scutellum lies well exposed. The metathorax is broader than long with highly sclerotized walls. The

scutal and scutellar regions have become small. The metatergum is attached with the first abdominal tergum while the metasternum has become completely fused with the first abdominal sternum. Malouf (1932) in Nezara included this part of the abdominal sternite into pterothorax which the present writer is not prepared to accept. The consolidation of different plates, the well developed postphragma and the furcal arms provide a firm support to withstand the great stress and strain of the various muscles of wings and legs.

(i) The neck

Much controversy existed in the past over the nature of cervix. Some early workers in the field regarded it as a separate segment and termed it "microthorax". The embryological work of Heymons (1899), Holmgren (1909) and others prove it to the contrary since there are not more than three neuromeres or metameres in the thorax of an insection embryo and other segmental structures also do not indicate more than three segments. The recent workers such as Martin (1916), Crampton (1917-26), Young (1921), Weber (1924) and Snodgrass (1935) on the basis of structural features have shown that the lateral neck plates form an intersegmental line between the head and thorax and include parts of both labial and prothoracic segments.

The cervix of Leptocorisa varicornis is membranous and is stretched over between the rim of the foramen magnum and the

anterior margin of the prothorax. The inner wall of episternum develops a pair of curved blunt sclesites called 'Cervical Sclerites' (Figs. 37, 39, 53 and 54: CvS), which articulate with the corresponding articular processes of the cranium formed at the lateral angles of the rim of foramen magnum. Hamilton (1931) termed them as 'Jugular sclerites' in Nepa. The postoccipital condyle simply rests on it and has no fibrous connections as suggested by Hamilton (1931) in Nepa. She has shown them as dorsal sclerites borne by the pronotum. The present writer considers cervical sclerites as lateral structures borne by the pleural plates of the prothorax and as such is not prepared to accept their tergal origin. He further considers that Hamilton's observations have not given due consideration to the tergo-pleural complex condition of the prothorax. Malouf (1932) in Nezara has not shown any 'sclerite-articulation' of thorax with the cranium. But the present writer susnects the ridge 'f' in Nezara as homologous to the cervical sclerite of Leptocorisa varicornis.

(ii) Structure of the prothorax

The prothorax is quite an independent segment having only membranous connections anteriorly with the head and posteriorly with the mesothorax. When viewed from above it appears to be of great size due to shield-like protergum. The terga, pleura and sterna are fused with each other. There is a distinct

tergo-pleural line of fusion but no such line of demarcation exists between the latter and the sternum. Their respective position can roughly be ascertained by the sterno-pleural line which extends into the thorax as extension of similar line in abdomen.

The protergum.— The protergum is a fairly distinct rectangular plate (Fig.36, T_1), and unlike the corresponding plates of the wing bearing segments it does not develop different sutures and ridges. It extends anteriorly to form a narrow collar-like plate (Figs.36, 37, 39, 53 and 54: acT_1), which covers over in normal position the posterior area of the head. Between the line of fusion of the anterior margin of protergum (Figs.36, 37, 53 and 54: amT_1) with the posterior margin of 'Collar plate' arises a feebly chitinized ridge to which is attached the neck membrane. The protergum develops posteriorly a large shield-like plate (Figs.36, 37, 39, 53 and 54: peT_1), which overlaps the whole of the mesoscutum. The posterior margin of the protergum (Figs.36, 37, 53 and 54: pmT_1), forms a distinct ridge to which is attached the intersegmental membrane. The posterior margin of the shield is more or less curved and forms slight lateral depressions thereby giving rise to three distinct lobes. The two dorso-lateral tubercles are small and lie over the axillary sclerites of mesothoracic wings while the margin of the middle lobe lies just above the concave anterior margin of mesoscutellum. The protergum, the collar plate and the shield are highly

pigmented. The protergum is the seat for the origin of certain muscles which pertain to the head and legs, while the collar plate and shield are simply secondary developments and have not much importance to their credit except that the former covers over the posterior area of the head and the latter provides protection to the mesoscutum above and the pre-alar bridge and dorso-lateral margins of the mesopleura.

The propectus.— It is a composite structure formed by the complete fusion of the propleura with the prosterna. It occupies the whole of the latero-ventral region of the prothorax.

The propleuron.— It is a distinct region formed by the union of the supra-coxal arches. Dorsally the propleuron has become fused with the protergum along a well defined tergo-pleural line (Figs.37, 53 and 54; TPIL). The pleural suture (Figs.37 and 38; pls_1), extends above from the pleuro-coxal process (Figs.37, 38, 39, 53 and 54; $Plcx_1pr$). It runs a short distance and is then lost. It carries internally the incomplete pleural ridge (Figs.39, 53 and 54; plr_1). This suture demarcates the pleuron into an anterior episternum (Figs.37, 38, 39, 53 and 54; Eps_1), and a posterior epimeron (Figs.37, 38, 39, 53 and 54; Epm_1). The episternum becomes narrow in its lower base and forms the precoxal bridge (Figs.37, 38, 53 and 54; $Prcx_1$), which brings it in continuity, ventrally, with the presternum (Figs.37, 38, 53 and 54; Prs_1). The episternal supracoxal arch develops a large episternal flap (Fig.37; Eps_1fl), which covers the coxa from the anterior surface. The cervical sclerites are situated at the

inner wall of the episternum (Figs.37, 39, 53 and 54; CvS). The epimeron forms posteriorly a short flap-like post-coxal bridge (Figs.37, 38, 39, 53 and 54; Pcx_1), which is responsible for providing continuity to the former with the prosternum. The flap-like postcoxal bridge is similar to the lateral epimeral flap of Nezara (Malouf 1932) and covers the underlying mesothoracic spiracle. The epimeral supra-coxal arch forms a short epimeral flap (Fig.37; Epm_1fl), which overlaps the coxa posteriorly. The pleural apophysis (Figs.37 and 38; $PlAp_1$), arises from the pleural ridge and extends over the postcoxal bridge. It then runs anteriorly almost beneath the infra-coxal arch and finally becomes fused with the prosternum. The inner end of the pleural apophysis is in close association with the outer end of the sternal apophysis of the corresponding side.

The trochantin (Figs.38, 53 and 55; Tn) arises as a small elongated sclerite from the inner margin of the episternum where the two supracoxal arches become united. It runs in antero-ventral direction and articulates with the anterior margin of the coxa. This presents the second pleural articulation to the coxa. The trochantin is narrow at the point of origin but anteriorly it expands thereby assuming a triangular shape. The anterior-most tapering forms the apex of the triangle and articulates with the corresponding concavity present on the anterior proximal margin of the coxa. The lower base of the triangle runs almost parallel to the coxal rim while the upper one provides attachment

to the tergal promotor of the coxa. The coxal articular concavity provides articulation to the pleuron at the pleuron-coxal process, a little posterior to the point of origin of the trochantin.

The prosternum.— It is a fairly well developed region. The eusternum is primarily divided into two parts by a distinct sternacostal suture (Figs.37 and 38; Scs_1), which internally forms a ridge called the sternacosta (Figs.39, 53 and 54; Sc_1). The basisternal area (Figs.37, 38, 39, 53 and 54; BS_1), which is placed anterior to this suture occupies a major portion than the posterior short strip-like furcasternal plate (Figs.37, 38, 39, 53 and 54; FS_1). The presternal suture cuts the basisternum into an anterior prosternum (Figs.37, 38, 53 and 54; Prs_1), and a posterior basisternum proper. The presternal ridge is the internal manifestation of the presternal suture. An external strong ridge (Fig.38; r), arises from the pleuro-coxal process and runs a short distance along the basal margin of the episternal flap. On reaching the basisternum it curves down and runs posteriorly almost upto the middle of the basisternal plate. It meets a similar ridge of the corresponding side near about in the middle of the basisternum. Again, after their union the ridges of the corresponding sides diverge posteriorly and run in a faint manner upto the sternacostal suture. The furcasternum (Figs.37, 38, 39, 53 and 54; FS_1), is a narrow plate having first spinasternite merged in it and lies posterior to the basisternum. The sternal apophyses (Figs.37, 38, 39, 53 and 54; Fu_1), arise as a

paired elongate arms from the eusternum. The bases of the furcae are united internally by the sternacosta. The free distal end develops a knob-like structure from which extends a short process. The sternal apophysis corresponds to the anterior horn of Nepa (Hamilton 1931). The furcasternum-cum-spinasternum develops posteriorly a pair of short flat apodemal processes (Figs.37, 38, 39, 53 and 54; fu_1), which are placed on either side of the anterior median lobe of the mesosternum. Hamilton (1931) in Nepa termed these as "posterior horns". The intersegmental position of the apodemal processes make it quite evident that these are similar to the median 'Spina' of other pterygote insects. The present writer, therefore, is not prepared to accept these as 'posterior furcae or horns' as suggested by Hamilton (1931). A fairly wide intersegmental membrane which connects the prosternum with the mesosternum is attached to the posterior margin of the furcasternum-cum-spinasternum.

(iii) Musculature of Prothorax.

(a) First levator of the head (Fig.39; No.23).— This is a thin muscle and originates from the anterior part of the protergum immediately behind the ridge 'em_1' and is inserted on the inner upper surface of the post-occipital process. It corresponds to muscle No.M_1 of the Nezara.

(b) Second levator of the head (Fig.39; No.24).— It is broader than the first and almost having a similar shape. It arises from the protergum a little posterior to the first and is attached to the outer upper surface of the postoccipital

process. It is similar to muscle No.M_2 of the Nezara.

(c) Indirect levator of the head (Fig.39;No.25).— It is a large bundle of muscle fibres running horizontally between the head and the mesonotum. It arises from the either sides of the median ridge of the prephragona and is inserted dorsally on the broad post occiput. It is similar to the 'first cranial flexor' of Nepa and "tergal longitudinal" of the Nezara.

(d) Depressor of the head (Fig.39; No.26).— This is thicker than the preceding muscles and has a dorso-ventral course. It originates anterior to the fore coxa from the basisternum and is inserted on the lower surface of the postoccipital process. It is equivalent to 'muscle No.M_4' of the Nezara.

(e) Promotor extensor of the head (Fig.39; No.27).— It is small and thin fan shaped muscle running posteroanteriorly. It originates near the cervical sclerite from the episternum and is inserted on the postoccipital ridge dorsal to the postoccipital process. It has been termed as 'muscle No.M_3' by Malouf(1932).

(f) Depressor-extensor of the head (Fig.39; No.28).— This is a fan-shaped muscle originating from the whole anterior surface of the furcal arms. It runs anteriorly and gets attached to the posterior margin of the gular plate. It has been named as "Ventro-longitudinal muscle" by Hamilton (1931) and "Sternal longitudinal" by Malouf (1932).

(g) Retractor of the propectus (Fig.39; No.29).— It is a small muscle and runs obliquely. It arises from the anterior tip of the prescutal process and is inserted on the base of the sternal furca. It indirectly elevates the head. This corresponds to the 'Tergo-sterno-furcal' of the Nezara.

(h) Depressor of the pronotum (Fig.39; No.30).— It is a large muscle with broad anterior and tapering posterior ends. It runs obliquely and originates from the inner margin of the prealare bridge. It is inserted on the middle region of the protergum. It corresponds to the 'Indirect protractor of fore legs'of the Nezara.

(iv) Structure of the fore legs.

There is a pair of movable legs (Fig.40 a) situated in the prothorax. These are chiefly used for walking and have pleural as well as trochantinal articulations. The fore legs are divided into five main segments viz. the coxa, the trochanter, the femur, the tibia and the tarsus (it splits up into three subjoints, the proximal being the basitrasus and the distal most, the pretarsus). Both monocondylic and dicondylic articulations are met with. The coxo-trochanteral, the trochantero-femoral and the femoro-tibial joints are dicondylic while the rest have monocondylic articulation. The coxa and trochanter do not bear any spine or hair-like process, while the femur and the tibia have short spines which are borne irregularly on their walls.

Besides, the tarsus has a thick hairy growth.

The coxa (Figs.40 and 56; Cx_1).— It is suboval in shape and is much broader in the proximal region. Proximally the coxa possesses a distinct rim which forms mesally an inflection (Fig.41; $miCx_1$). The latter develops at its apex a small concavity (Figs.41 and 55; Con_1), for the articulation of the pleurocoxal process. Anterior to the inflected portion there is another concavity (Fig.41; Con_2), on the coxal rim to which is articulated the apex of the trochantin. Thus the coxa has a pleural as well as the trochantinal articulation with the body. A thin membrane, the coxal corium, which surrounds the proximal base of the coxa, provides an attachment to the latter with the rim of the coxal socket. The coxa is thus well placed inside the coxal socket (Figs.38, 39, 53 and 54; Cx_1c) and there is absolutely no chance of its being dislocated.

The proximal base of the coxa bears a sub-marginal suture, the basicostal suture (Figs.41 and 55; bcs), which runs along the basal rim and extends over the inflected portion of the coxa to give completion to its course which is all along the margin of the coxa. The basicostal suture bears internally a ridge called basicosta, which follows a similar course and demarcates an anterior marginal area, the basicoxite (Figs.41 and 55; Bcx) from the rest of the coxa.

A marginal ridge (Fig.42; mrdrCx) runs throughout the broad distal end of the coxa. The distal rim also possesses a pair of articular knobs (Figs.42 and 43; Ark_1) at its anterior and posterior angles. The articular knobs face towards the lumen of the coxa (Fig.42; Lum) and provide a dicondylic articulation to the trochanter. A thin conjunctival membrane connects the distal coxal rim with the proximal rim of the trochanter.

The trochanter.— It is the smallest segments of the insects' leg. Its walls are highly sclerotized and the lumen is reduced due to the formation of distinct and broad marginal inflections from the proximal and distal rims. The dorsal surface of the trochanter is short and almost concave. The ventral surface which is longer than the dorsal surface is slightly convex.

The dorsal half of the proximal rim is concave and carries mesally a short, flat and disc-like sclerotized plate (Figs.43 and 54; dAppl) for the attachment of the muscles. The ventral half develops laterally two articular knobs (Fig.43;Ark_2) while its central portion (Fig.43, PvrTr) is raised to provide attachment to the depressor's apodemal plate. The articular knobs rest on corresponding coxal articular knobs to enforce dicondylic articulation. The dorsal wall of the trochanter is short and less extended as compared to the ventral one. This results into an oblique distal trochanter's lumen. On the other hand, the proximal end of the femur presents just a reverse condition and the dorsal and ventral halves of its proximal rim

meet those of the corresponding rim of the trochanter obliquely. A small articular knob (Fig.43; Ark_3) is present in the centre of the ventral half of distal rim (Fig.DvrTr) of trochanter. It is articulated with a concavity present in the centre of the ventral half of the rim of femur. The movement of the trochanter on the femur is that of production and reduction and is regulated by a single reductor muscle. A short membrane is present at the trochantero-femoral joint. This joint is firm enough and therefore the femur moves as a whole with coxo-trochanteral articulations as a pivot.

The femur.— It is the longest segment of the leg with comparatively longer dorsal and small ventral walls. The proximal portion is narrower than the distal one. The dorsal half of the proximal part of femur (Fig.44; PdrFe) bulges out towards the trochanter and forms a convexity at its apex. The ventral half (Fig.44; PvrFe) bears mesally a small concavity (Fig.44; Con_3) into which rests the articular knob of the ventral half of the distal rim of trochanter.

Towards the distal end of the femur, the dorsal wall (Fig.45; DdrFe) runs its normal course while the ventral wall undergoes a bell-shaped emargination (Fig.45, 46 and 57; emDvrFe). The distal end of the femur possesses a pair of lateral articular knobs (Figs.45, 46 and 57; Ark_4). These articulate with the corresponding articular knobs of the tibia to provide dicondylic

articulation. The area of the femoro-tibial joints is occupied by conjunctival membrane.

The tibia.— It is almost of the same size as the femur. Its proximal and distal ends are comparatively broader than the narrow mesal part. It is lightly bent at its proximal end. The dorsal half of the proximal rim (Figs.46, 47, 57 and 58; PdrTb) is convex while the ventral half (Figs. 46, 47, 57 and 58;PvrTb) is concave. An apodeme (Figs.46 and 57; Ap_2) which provides attachment to the levator muscles of the tibia is connected with the dorsal half of the proximal rim by a short thin membrane. The lateral angles of the ventral half are modified into articular knobs (Figs.46, 47, 57 and 58; Ark_5) for the femoro-tibial articulation. To the ventral half of the proximal rim is attached a rectangular plate, the genuflexor plate (Figs.47 and 58;gfpl), which is the expanded end of the depressor's apodeme (Figs.47 and 58; Ap_3).

The dorsal wall of the tibia near the distal end (Fig.48; DdrTb) bears an internal projection whose ventral surface has developed a concavity (Fig.48; Con_4) to allow articulation to the proximal end of basitarsus. It is a true representation of the monocondylic articulation. The ventral half of the distal end of tibia (Fig.49; DvrTb) undergoes slight emargination and bears mesally a pair of short spines. The ventral wall also carries on its lateral sides unpaired similar spines. A regular row of short, fine and hair-like processes is situated between

the median and lateral spines. This bristle brush or comb assumes the name "antenna cleaner" (Fig.49: Antcln) by virtue of its being used by the insect in cleaning the antennae. The antenna is held between the median and lateral spines and is then slowly withdrawn. The foreign particles adhere to the bristle comb. The process is repeated again and again till the antenna becomes free from all foreign matters.

The tarsus.— It is shorter than femur and tibia. It is divided into three sub-segments, the tarsomeres. The proximal tarsomere is the largest and is known as basitarsus (Figs.40, 48, 50 and 59; BTar). The narrow proximal end of the basitarsus (Fig.48; PrBTar) extends towards the tibia and fits closely in the concavity present on the dorsal wall of the distal end of the tibia. There is a crescent-shaped concavity (Fig.50; Cong) towards the distal end of the basitarsus. The proximal end of the second tarsomere (Fig.50; Tar_2) which is the smallest sub-joint of tarsus, articulates within the concavity of the distal end of the basitarsus. A thin membrane is present between the two joints.

The pretarsus (Figs.40 and 51; PTar) is the distal most sub-segment of the tarsus. The proximal end is similar to those of the preceding sub-joints while the distal end has undergone certain modifications. The dorsal wall becomes inflected mesally and carries a small plate, the unguifer (Fig.51; Ung). On either side of the latter is articulated a claw (Figs.51 and 52; Cla). The lateral hollow claws are broader at the proximal end

and taper out distally into blunt apices.

The ventral wall of the distal end is shorter than the dorsal wall and carries comparatively a long and broad plate, the unguitractor (Fig.52: Utr). The latter is invaginated at its proximal end and bears a long apodeme called depressor apodeme of pretarsus (Fig.52: Ap_5), which extends from the proximal region of the femur to the basal invagination of the unguitractor. Laterally on either side of the distal end of unguitractor are situated two small oblong plates, the auxillae (Fig.52: aux). Each auxillia carries anteriorly a lobe-like structure, the pulvillus (Fig.52: plv). A little posterior to the distal most margin of the unguitractor arise a pair of elongated spine-like processes (Fig.52: sp), which may be compared to the median-spine-like process, the empodium.

(v) Musculature of the fore-legs

First promotor of coxa (Figs.53 and 55; No.31).— This is a large bundle of muscle fibres and originates mesally on the middle of the protergum a little anterior to the depressor muscle of the pronotum. Its fibres are inserted on an apodeme which is attached to the upper part of the distal end of the trochantin. It has not been described by Malouf.

Second promotor of coxa (Figs.53 and 55: No.32).— It is almost of the same size as the first and originates from the tergum anterior to the first promotor. It is attached on an

anodeme which arises from the base of the coxa anterior to the coxal process. It resembles 'Tergal promotor of coxa' of the Nezara.

Third promotor of coxa (Figs.53, 54 and 55; No.33).— It is smaller than the preceding two muscles. It arises from the lower limits of the episternum and occupies the anterior most position among all the promotor muscles of the fore legs. It is inserted on the same anodeme on which the second promotor muscle is attached. Malouf (1932) in Nezara described it as 'Sternal promotor' arising from the ridge 'f' and having an indenendent insertion on a separate anodeme. It is quite clear from his Fig.1, Pl.13, that the ridge 'f' is episternal in position. Thus the third promotor muscle of Leptocorisa is similar, being episternal in origin, but differs in its insertion.

First remotor of coxa (Figs.53 and 55; No.34).— This is the largest muscle of the fore coxa with its distal flat surface directing entero-posteriorly. Its fibres arise from the posterior part of the protergum and end on a strong tendon which is attached to the coxal rim posterior to the coxal process. It is the chief remotor of coxa and corresponds to 'Tergal remotor of coxa' of the Nezara.

Second remotor of coxa (Figs.53, 54 and 55; No.35).— This is a small muscle originating from the lateral sides of the sternal furca and inserts near the first remotor on the margin of the coxa posterior to the coxal process. It has been named as 'Sternal

remotor' by Maloof (1932).

Tergal depressor of trochanter (Figs.54 and 56; No.36).— It is a long and narrow muscle arising from the mesal part of the protergum and is inserted on an apodeme which rests on the ventral wall of the proximal end of trochanter. It corresponds to 'tergal branch of depressor of trochanter' of the Nezara.

Pleural depressor of trochanter (Figs.54 and 56; No.37).— This is a large flat muscle. It originates from the dorsal margin of the pleuron and is inserted on the same apodeme which provides attachment to its tergal branch. It is equivalent to the "pleural branch of depressor of trochanter" of the Nezara.

Coxal depressor of trochanter (Fig.56; No.38).— This is a thick bundle of muscle fibres originating mesally on the ventral side from the proximal margin of the coxa. It is also attached on the same apodeme which gives insertion to its tergal and pleural branches. It is similar to the corresponding muscle of the Nezara.

Levator of trochanter (Fig.56; No.39).— It is also in the form of a thick bundle. Its fibres arise mesally on the dorsal side from the proximal margin of the coxa and are inserted on an apodemal plate which is placed on the dorsal wall of the proximal end of the trochanter. It is similar to the same muscle of the Nezara.

Femoral reductor (Fig.56; No.40).— It is a small fan-shaped muscle and runs obliquely within the trochanter. Its fibres

originate from the dorsal wall of the trochanter and converge to get inserted on the posterior half of the proximal ventral margin of the femur. It corresponds to the'remotor of femur' of the Nezara.

Extensor of tibia (Fig.57; No.41).— It is a pinnate muscle with its fibres arising from the dorsal wall of the femur. They are inserted on an axial apodeme which ends on the dorsal wall of the proximal end of the tibia. It resembles with the 'levator of tibia' of the Nezara.

Depressor of tibia (Fig.58; No.42).— It is similar to the extensor muscle and originates from the ventral wall of the femur. It is attached on a similar tendon which rests on the genuflexor plate of the proximal ventral wall of the tibia. Malouf (1932) in Nezara has shown that few of its fibres arise from the trochanter anterior to the femoral remotor muscle. The present writer could not find its fibres beyond the proximal ventral wall of the femur.

Depressor of tarsus (Fig.59; No.43).— This is also a pinnate muscle and occupies about three-fourth part of the tibia. Its fibres arise from the ventral wall of the tibia and are inserted on a thin tendon which extends from the proximal ventral wall of the basitarsus.

Levator muscle of tartus is absent.

Depressor of pretarsus (Fig.60; No.44).— There are two depressor muscles of the pretarsus. The first or the proximal

depressor muscle (No.44 a) arises mesally from the proximal end of the femur and is placed between the extensor and depressor muscles of the tibia. The second or the distal bundle (No.44 b) originates from the proximal dorsal wall of the tibia. Both these bundles are inserted on the same apodeme which arises from the unguitractor plate of the pretarsus. The proximal bundle occupies about one-third part of the proximal femoral end while the distal one is confined only to the one-fourth area of the proximal end of tibia. Both these bundles are similar to those described by Malouf (1938) in Nezara.

(vi) Structure of the mesothorax

The mesothorax is largest among all the thoracic segments and occupies about two-third area of the latter. The mesonotum is fairly large and its scutalar region is kept covered by the posterior shield-like extension of the protergum. The scutellum extends a long distance posteriorly upto the middle of the metanotum. The mesonotum is separated from the respective mesopleuron by a distinct narrow space extending along the dorsal margin of mesopleuron. This space is traversed by a thin membrane which connects it with the mesonotum. The dorsal shield of the protergum laterally extends a little distance over the dorsal part of the mesopleura and this can rightly be called as "Dorso-lateral" instead of merely "Dorsal" shield. The mesopleura and mososterna become fused to form the mesopectus. The close approximation of

the sclerotized parts of the mesothorax together with the upward curvature of the mesonotum make it capable of withstanding the great pressure exerted by the muscles of the legs and wings of this segment.

The mesonotum.— It is a large arched plate and is divided into three distinct regions viz. prescutum, scutum and scutellum. The prealar bridge (Figs.61, 64, 65 and 66; PrAB) extends ventrally and has membranous connection with the episternum. It thus gives support to the mesonotum. A thin intersegmental membrane arises from the anterior margin of the prescutum and connects the mesonotum with the posterior margin of the pronotum. The prescutum bears an unpaired prephragma (Figs.61, 64, 65 and 66; 1 Ph) which hangs downwards from the middle of its anterior margin. The free end of the prephragma bears mesally a small emargination (Fig.61:em) which works as a passage for the aorta. A small ridge (Fig.61;mr) is developed on the ventral surface of the prephragma and is in continuation with the median carina of the scutum. This median ridge divides the prephragma into two equal lobes.

The prescutum.— The prescutal suture (Figs.61, 65 and 66;ts) traverses the whole length of the anterior region while laterally it extends upto the anterior notal wing processes. The prescutal suture demarcates the marginal prescutal area (Figs.61, 65 and 66; Prsc) from the large scutum. The prescutum is broad in the anterior region and laterally it becomes inflected downwards leaving its suture as pseudo-lateral margin of the scutum. The

prescutum carries anteriorly a pair of short and slender processes (Figs.61, 64, 65 and 66; Prscl) which are situated on either side of the prephragma. Malouf (1932) regards that the prescutal suture is well marked in the region of the prealar bridge and does not extend as far mesally as the parapsides of its sides. The prescutum forms a pair of small processes called "anterior notal process" near its latero-posterior angles. This confirms Alam's (1951) view of "prescutal origin of anterior notal processes" in stenobracon deesae. The anterior notal processes provide support to the neck region of the first axillary sclerites of the fore wings. Malouf (1932) termed the anterior and posterior lobes of the anterior notal wing process as vecta dorsualis anterior and vecta dorsualis posterior respectively.

The mesoscutum.— A transverse but more or less concave groove (Fig.61; vs) divides the mesonotum into an anterior large scutum and a posterior comparatively small scutellum. The inverted 'V-shaped' condition is no doubt absent but this in no way binds the opinion of the present writer to consider this groove as "Scuto-scutellar suture". The scutum is primarily divided longitudinally into two halves due to the presence of a median groove (Fig.61; mf) which internally forms the median carina. The median groove extends from the prescutum to the scuto-scutellar suture. The scutum in the posterior half is further divided into two lateral and one mesal areas by a pair of short curved grooves (Figs.61, 64, 65 and 66; pg). These start from the posterior half

of the lateral margins and running in meso-posterior direction end on the scuto-scutellar suture. The present writer would prefer to call them "posterior intra-scutal groove" rather than trans-scutal or parapsidal suture. The areas thus divided become an upward large central (Figs.61, 64, 65 and 66; Sct_2) and a pair of small postero-lateral areas (Figs.61, 64, 65 and 66; sct_2).

The mesoscutellum.— It is a large triangular plate (Fig.61; Scl_2) lying posterior to the mesoscutum. Its apex extends as far posteriorly as the posterior margin of the postnotum. The 'V' shaped reversed notal suture (Fig.61; rvs) runs on its lateral sides and divides the scutellum into a median elevated plate (Fig.61; Scl_2) and the two lateral depressed regions (Figs.61, 64, 65 and 66 scl_2). The former is more sclerotized than the latter. The antero-lateral margin of the lateral scutellar plate develops anteriorly two short processes. The dorsal posterior notal wing process (Fig.61; PNP_2) provides articulation to the third axillary sclerite and the distal end of the axillary cord of fore wing. The ventral process gives articulation to the large postnotum (also known as phragmanotum due to its association with the meso-nost-phragma). The postnotum (Figs.61, 64, 65 and 66; PN_2) lies ventral to the scutellum and thus supports the latter from below. The phragmanotum termed as "postscutellum" by Malouf (1932) in Nezara, extends posteriorly upto the median notch of the meta-scutum. Its anterior margin forms a deep emargination and is kept free from the inner surface of the scutellum, while the antero-lateral margin develops the postalar bridge (Fig.61; PAB) and

becomes fused with the mesal inflection of the epimeron. An elongated independent sclerite "supporting plate of sub-alar" is articulated with a small dorso-lateral projection of the postnotum. Weber regards the supporting plate of subalar as fourth axillary while Malouf (1932) considers it to be an apodeme.

The mesopostphragma.— It is a highly developed U-shaped structure (Fig.62; 2Ph) with its lateral and ventral walls continuous with one another. It has become fused dorsally with the postnotum while its dorsolateral walls get fused with the lower part of the metascutal carina. It is thus closed from all the sides (Figs.62 and 64) except the anterior region and hanges freely within the pterothorax. The antero-ventral margin forms an emargination. The visceral organs sink down and pass beneath its ventral walls. The anterior margin of the postphragma is fused laterally with the outer margin of the epimeron. It thus occupies an intersegmental position between the meso- and metathorax, and the methathoracic spiracle lies within it. A little posterior to the anterior margin, the postphragma develops a sclerotized ridge (Figs.62, 64, 65 and 66; rPh_2) which runs in latero-ventral direction. This ridge divides the postphragma into a small anterior lamella (Figs.62, 65 and 66; Antlm) and a long posterior lamella (Figs.62 and 64; Postlm). The former provides attachment to the secondary indirect levator of the fore wings while the latter gives insertion to the indirect and principal depressor of the fore wings.

The mesopectus.— The pleural and sternal regions of the mesothorax have undergone complete fusion and as such the latero-ventral walls form a complex cup-shaped structure, the mesopectus.

The mesopleuron.— The walls of the mesopleuron are highly sclerotized except at its dorsal region where it is less chitinized. The pleural ridge arises from the pleurocoxal process (Fig.62; $PlCx_2pr$) and after running a short distance it becomes obliterated. It reappears in the dorsal region of the mesopleuron and then extends as a dorso-ventrally flattened ridge where it bears the pleural wing process (Figs.62, 65 and 66; PWP_2). The pleural ridge appears extenally as "pleural suture" (Fig.62;pls_2). It divides the mesopleuron into an anterior large episternum (Figs.62, 65 and 66; Eps_2) and a posterior narrow epimeron (Figs.62, 65 and 66; Epm_2). Each region carries ventrally a cuticular flap which is similar to that of the preceding segment. The episternal flap (Fig.62; Eps_2fl), is comparatively larger than the epimeral flap (Fig.62; Epm_2fl). The precoxal bridge is quite distinct while the postcoxal bridge has become too much reduced. The trochantin which is similar to that of the propleuron in its origin, articulation and shape has proportionately increased in size. The pleural apophysis, which appears as a ridge arises near the pleurocoxal process and runs almost along the infracoxal arch. It is in close association with the base of the sternal apophysis.

Besides the pleural ridge there are other secondary ridges which are mostly confined to the episternal region. From the lower limits of the dorso-ventrally flattened arm (Figs.62, 65 and 66: PWP_2) of the pleural ridge extends a large ridge (Figs.62, 65 and 66; a) which runs anteriorly in a curved state. There are two off-shoots of ridge 'a'. Its posterior ridge (Figs.62, 65 and 66; b), arises from the concavity and directs ventrally, while the anterior ridge (Figs.62, 65 and 66; c), arises from the convexity and directs dorsally. The dorsal most margin of the mesopleuron is traversed by a marginal ridge (Figs.62, 65 and 66: d) which runs antero-ventrally and gets merged in ridge 'a'. The prealar bridge of the mesonotum is fused with its anterior margin and the mesothoracic spiracle (Fig.62; sp_1) lies dorsal to it. The pleural ridge together with the ridges 'a' and 'd' encloses dorsally a narrow triangular area. The wall of the episternum within this triangle is feebly chitinized. The ridge 'a' as will be shown later, forms a hinge line, while its branches provide firm attachment to certain leg and wing muscles.

The dorso-ventrally flattened arm of the pleural ridge forms a black knob at its dorsal end. A small crescent shaped black sclerite, the basalare (Figs.62, 65 and 66; Ba_2) rests on its dorsal convexity. A large oval plate, the basalare apodeme (Figs.62, 65 and 66; Ba_2Ap) which is bounded anteriorly and posteriorly with the ridge 'a', hangs down by the antero-ventral extension of the dorso-ventrally flattened arm of the pleural

ridge. The basalare is thus in direct communication with the basalare apodeme. The pleural wing process provides articulation to the second axillary at its dorso-posterior concavity (Fig.62; $ConAx_2$).

The epimeron bears internally a dorso-ventral carina (Fig.62; $dvcEpm_2$). It is much expanded dorsally and forms a mesal inflection (Fig.62; $miEpm_2$), to which is attached the phragmanotum. The anterior margin of the postphragma, which runs latero-ventrally, has membranous connections with the posterior margin of the epimeron. The dorsal margin of the epimeron develops posteriorly a rounded structure (Figs.62, 65 and 66; kb) which corresponds to the "Button-like-knob" of Nepa described by Hamilton (1931). The concavity of the costal region of the fore wing lies upon this knob when the wings are in repose. Posterior to the pleural wing process and lying over the dorsal margin of the epimeron is a distinct small triangular sclerite, the subalare (Figs.66 and 75; Sa_2).

Malouf (1932) in Nezara described the basalare apodeme as the ventral plate of the anterior extension of the pleural arm, and the subalare as an apodeme to which the second flexor muscles of the fore wing is attached. He regards that the basalare and subalare sclerites are absent in Nezara. Snodgrass (1935) considers that the subalare is nearly always a distinct sclerite in adults and the basalare is frequently but an imperfectly separate lobe of the episternum. Furthermore it becomes quite evident from

the function of the muscles belonging to them in Leptocorisa varicornis, that the sclerites under discussion are the basalare and subalare. Malouf's (1932) claims that these are absent in Nezara appears to be inappropriate. The epipleurites described by Taylor (1918) and Quadri (1950) in Belostoma and Pyrilla respectively correspond to the basalare and subalare sclerites of Leptocorisa varicornis.

The mesosternum.— The eusternum of mesothorax is a dome-shaped sclerite limited posteriorly by the intersegmental groove (Fig.63; Isgr) which demarcates it completely from the metasternum. The sterna-costal suture internally forms a ridge, the sternacosta (Fig.63; Sc_2) which carries at its either extremity the long sternal furcae (Figs.62, 63, 65 and 66; Fu_2). The sternacostal suture divides the eusternum into a large anterior basisternum (Figs.62, 63, 64, 65 and 66; BS_2) and a posterior very narrow sternellum (Figs.62, 63, 64, 65 and 66; FS_2). An external ridge (Fig.63; X) runs parallel to the outer wall of the episternal flap and posteriorly becomes absorbed in the basisternum. The internal ridge (Fig.63; Y) which runs in postero-anterior direction, encloses mesally an oblong basisternal plate (Fig.63; OBS_2pl). The sternellum is a narrow plate and gets merged posteriorly into the intersegmental groove. From the base of the sternacosta arise a pair of long and slender arms, the sternal furcae. The latter extend towards the dorsal wall of the mesopleuron and develop at their extremity a large cup-shaped structure (Figs.62, 63, 65 and

66; Fu_2). Malouf (1932) regards the sternacosta as the antecostal ridge from the lateral parts of which arise the sternal furca.

(vii) Musculature of the mesothoracic wings

Indirect and principal depressor of the fore wings (Fig.64; No.45).— This is the largest and stoutest bundle of muscle fibres running dorsally in antero-posterior direction. Its fibres originate on either sides of the median ridge from the prephragma and the antero-ventral wall of the mesocutum and are inserted on the whole of the latero-ventral area of the mesopostphragma. It has been named as 'tergal longitudinal' by Malouf (1932).

Secondary indirect depressor of the fore wings (Fig.64; No.46).— These are very small muscles with short fibres. It originates on the sternal furca of the mesothorax and is inserted on the outer ventral surface of the anterior lamella of the second thoracic phragma. It corresponds to the 'tergo-sterno-furcal' of the Nezara.

Indirect and principal levator of the fore wings (Fig.64; No.47).— It is broad and strong bundle with its fibres arising laterally from the mesoscutum to get inserted on the large basisternum. It runs dorso-ventrally and elevates the fore wings. It is similar to the 'tergo-sternal' of the Nezara.

Secondary indirect levator of the fore wings (Fig.64;No.48).— It is a strap-shaped muscle and originate from the posterior lateral part of the mesonotum which is enclosed by the ridge 'pg' and are attached on the inner ventral part of the anterior lamella of the postphragma. It runs obliquely and acts as an accessary levator muscle. It resembles 'tergal longitudinal oblique' of the Nezara.

Flexor of the fore wings (Figs.65 and 66; No.49).— It is an elongated muscle lying between the ridges 'a' and 'd' of the meso-enisternum. Its fibres arise from the ridge 'd' and are attached on the anterior surface of the elongated proximal arm of the third axillary. It is equivalent to the "first flexor of fore wing" of the Nezara.

Promotor-extensor of the fore wing (Figs.65 and 66;No.50).— It is an almost circular muscle with short dense fibres. It arises from the whole of the ventral surface of the basalare apodeme and gets inserted on the dorsal surface of the distal broad base of the sternal furca. It is similar to 'Sterno-pleuro-apophysal' muscle of the Nezara.

Depressor-extensor of the fore wing (Fig.66; No.51).— It is an elongated spindle-shaped muscle. Its fibres originate dorsally from the internal apodeme of the subalare sclerite and becomes attached ventrally on the posterior proximal margin of the coxa. It has been described as "Second flexor of fore wing" by Malouf (1932).

Intersternal muscle between pro- and mesosternal furcae (Figs.64, 65 and 66; No.52).— It is a long and slender muscle with very few fibres. It arises from the posterior surface of the prothoracic furca and is inserted on the anterior surface of the meso-sternal furca. It runs longitudinally along the inner side of the indirect principal levator muscle of the fore wings. It brings about firmness to the intersegmental connections between the pro- and mesosternum. It corresponds to the "sternal longitudinal muscle" of the Nezara.

(viii) The mesothoracic legs (Fig.40b).--

These are slightly larger in size than the fore legs. The structure of the different segments and sub-segments together with their mode of articulation is almost similar to the legs of the preceding segment. The absence of "antenna cleaner has brought about few changes in the structure of the distal end of tibia. The ventral emargination has therefore become less prominent and the median and lateral spines have altogether atrophied.

(ix) Musculature of mesothoracic legs

First promotor of coxa (Figs.65 and 66; No.53).— This is a long and thin bundle and originates from the anterior part of trans-scutal ridge 'pg' of the mesonotum. Its fibres are attached on an apodeme which arises from the upper distal end of the trochantin. Malouf described it as "tergal promotor of coxa"

having its insertion directly on the anterior margin of the mesocoxa.

Second promotor of coxa (Figs.65, 66 and 67; No.54).— It is a thin flat muscle and arises mesally on the anterior dorsal margin of the episternum from the ridge 'c'. Its fibres end on apodeme which is attached to the anterior margin of the proximal coxal rim. Malouf (1932) termed it as 'sternal remotor' originating from the ridge 'n' of the episternum.

First remotor of coxa (Figs.65 and 67: No.55).— It is a fairly large bundle of muscle fibres. It originates from the anterior margin of the lateral scutellum (scl_2) and are inserted on a strong tendon which arises from the posterior proximal margin of the coxa. Malouf termed it as 'tergal remotor of coxa' and regards its origin from the lateral posterior part of the scutum.

Second remotor of coxa (Figs.65 and 66; No.56).— It is a small bundle of muscle fibres having direct connection on the coxa. Its fibres originate from the outer surface of the proximal furcal base and are inserted posterior to the first remotor on the posterior proximal margin of the coxa. It corresponds to the "Sternal remotor" of the Nezara.

Tergal depressor of the trochanter (Figs.66 and 67;No.57).— It is the thinest and narrowest muscle. Its fibres originate posterior to the first promotor muscle from the transcutal ridge of the mesonotum and end on a strong apodeme which arises from

the proximal ventral wall of the trochanter.

Pleural depressor of trochanter (Figs.66 and 67; No.58).— It is the largest leg muscle situated in the mesothorax and lies flat along the inner wall of the pleuron. It arises mesally from the ventral surface of the ridge 'a' and partly from ridge 'b'. Its fibres are attached on the same apodeme upon which its tergal branch is inserted.

The tergal and the pleural depressors of trochanter are similar in origin and insertion to the "Depressor of telopodite" of the Nezara.

The muscles of the remaining segments and sub-segments of the mesothoracic legs are almost similar in their origin and insertion to that of the fore legs.

(x) Structure of the metathorax

The metathorax is slightly broader than long and is fairly developed on its lateral sides. Mesally it carries the mesopostnotum with which is incorporated its actrotergite. The metanotum is separated from the metapectus by a tergopleural line (Figs.69, 72 and 73; TPIL). The pleuron is fairly developed and is completely fused with the sternum. The latter carries the sternal furcae and the highly specialised stink grooves.

The metanotum.— It is a fairly developed sclerite lying flat between the mesothorax and the first abdominal segment.

Laterally it is fused with the metapleuron by a distinct tergo-pleural line of fusion (Figs.69, 72 and 73; TPIL). The metanotum is divided by a V-shaped pseudo-scuto-scutellar suture (Fig.69; vs) into a median narrow scutum (Fig.69; Sct_3) and a large scutellum (Fig.69; Scl_3). This suture forms internally a carina to which is attached the mesopostnotum and the postphragma.

The anterior margin of the scutum forms a deep cup-shaped emargination (Fig.69; em) and is deeply notched in the middle (Fig.69; n). The inner margin of the scutum forms anteriorly on either side two sclerotized arms. The first or the outer arm (Fig.69; $oaSct_3$) extends anteriorly in the form of a thin stripe and becomes fused with the episternal lobe. The second or the inner arm (Fig.69; $iaSct_3$) runs as a marginal ridge and gets fused with the anterior margin of the scutellum. Between the two arms is left a fairly large space. Within it lies an oblong semi-detached plate (Figs.69, 71 and 79; sct_3). It has membranous connections with the two arms of the scutum. A submarginal ridge (Figs.69 and 79; r) runs in its anterior and lateral sides in such a fashion that it divides the plate into three unequal parts. The anterior lobe forms a small inflection, the anterior notal wing process (Figs.69 and 79; ANP_3), to which is attached the first axillary. The lateral lobe bears the posterior notal wing process (Figs.69 and 79; PNP_3), to which is articulated the third axillary. That this plate belongs to the scutum is borne out by the fact that besides supporting the first and third

axillaries, it provides insertion to the indirect depressor muscle (tergal longitudinal) of the hind wing.

The scutellum (Fig.68; Scl_3) is fairly developed on its lateral sides while posteriorly it has become very narrow. On either side of its lateral parts runs a strong ridge. It is fused anteriorly with the anterior margin of the scutellum, while posteriorly it extends along the tergo-pleural line as far posteriorly as the epimeral flap of its side. The anterolateral margin of the scutellum gets fused with the inflected margin of the epimeron. The scutellum carries posteriorly a small rod-like sclerite, the postscutellum (Fig.68; $PScl_3$), which internally bears the metathoracic phragma (Figs.69, 71, 72 and 73; Ph_3). The latter is fairly developed laterally while mesally it is very narrow. The metaphragma extends downwards and is connected with the epimeron. Malouf (1932) refers an unusual case of its fusion with the episternum. As a matter of fact he failed to trace out the actual course of the pleural suture and confused the epimeron with the episternum.

The metapectus.— The metapleura are so firmly fused with the metasterna that there is no trace of pleuro-sternal line of fusion. The metapectus occupies the whole of the latero-ventral area of the metathorax.

The metapleuron.— It is a fairly developed sclerite lying between the mesopleuron and the first abdominal segment. Dorsally it is separated from the metanotum by a clear tergo-pleural line

(Figs.69, 72 and 73; TPII). The pleural suture (Figs.69, 71, 72 and 73; pls_3) arises from the dorsal surface of the pleuro-coxal process (Figs.69 and 70; $PlCx_3pr$). It runs a short distance along the basal fold of the epimeron and then disappears. It reappears in the dorsal region where it runs in postero-anterior direction almost parallel to the tergo-pleural line. Anteriorly it lies beneath a short arm, the pleural wing process (Figs.69, 71, 72 and 73; PWP_3). The latter is situated towards the posterior margin of the anterior lobe of metapleuron (Figs.69, 71, 72 and 73; anM). Tower (1914) in Anasa tristis mistook the stink groove as the pleural suture. Taylor (1918) while correcting the mistake of Tower regards the groove along which the free flange meets the episternal proper as the obsolescent pleural suture, and thus erroneously assumes the posterior part of the episternum as epimeron. The pleural suture which internally carries the pleural ridge (Fig.70; plr_3) divides the metapleuron into a large episternum (Figs.69, 71, 72 and 73; Eps_3) and a narrow epimeron (Figs.69, 71, 72 and 73; Epm_3). The cuticular flaps of the episternum and the epimeron are completely fused with one another and therefore can be collectively called as the metapleural fold (Figs.69 and 70; mplf1). Malouf (1932) in Nezara regards that the epimeron is insignificant and the episternum bears a ventral and a lateral flap. The present writer believes that the ventral flap of Nezara is the metapleural flap since its inner rims are episternal and epimeral in origin and is

similar to those of the preceding segments. The lateral episternal flap of Nezara is the epimeral flap because it is the dorsal extension of the epimeron and its base does not go beyond the pleural suture towards the episternum. The trochantin is quite distinct and with the increase in size of the hind leg has become enlarged. It is exactly similar in origin, articulation and structure to that of the preceding segments.

The episternum forms dorsally a small lobe (Figs.69, 71, 72 and 73; anT) which, at its posterior margin, bears the pleural wing process (Figs.69, 71, 72 and 73; PWP_3). The anterior margin, which is continuous from the dorsal lobe, has become inflected to gets fused with the mesopleuron. The anterior margin carries ventrally a flap (Figs.69, 70, 71, 72 and 73; Eps_3fl), which is in communication with the epimeral flap of the mesopleuron and thus covers a portion of the mesocoxa. The pleural wing process develops posteriorly a small concavity to which is articulated the second axillary. The basalare (Figs.69 and 72; Ba_3) is much reduced and is represented by a small semi-detached sclerite hanging down from the dorsal margin of the episternal lobe. The precoxal bridge (Figs.69, 71 and 73; $PrCx_3$) is well developed in the metathorax. The shallow stink groove (Figs.69, 70, 71, 72 and 73; Stgr) which is narrow and tube-like in its posterior region, becomes expanded anteriorly. It extends anteriorly from the base of the metapleural flap and divides the precoxal bridge into an anterior laterale and a posterior antecoxal parts. The anterior laterale is fused dorsally with the

episternum and ventrally with the basisternum. An elongated stink fold (Figs.69, 70, 71, 72 and 73; Stfld) which is present on the anterior laterale is reflected back over the stink groove (Figs.69, 70, 71, 72 and 73; oStgl) and partly covers the latter. The antecoxal laterale is fused anteriorly with the anterior margin of the furcasternum and posteriorly with the metapleural flap.

Dorsally the epimeron (Figs.69, 71, 72 and 73; Epm_3) exists as a narrow sclerite between the tergo-pleural line and the pleural suture. The epimeron is represented posteriorly by a latero-ventral flap (Figs.69, 70, 71, 72 and 73; Epm_3fl) which is the dorsal extension of the epimeron. From the base of the epimeral flap arises an internal fold (Figs.69, 70, 71, 72 and 73; Epm_3fld) which extends ventrally and becomes fused with the sternum. This fold is, as a matter of fact, the first abdominal pleuro-sternal plate which has become completely fused with the metapectus and is taken as a part of the latter. The metaphagma extends ventrally and gets fused with the base of the epimeral fold. The postcoxal bridge is vestigeal. The pleural apophysis is much reduced and runs as a marginal ridge along the posterior margin of the coxal socket (Figs.69, 70, 71, 72 and 73; Cx_3c). The subalare (Figs.69, 71 and 72; Sa_3) lies as a free sclerite towards the inflected margin of the narrow dorsal epimeron. Malouf (1932) regards the basalare and subalare as absent.

The metasternum.— The pleuro-sternal elements of the metathorax are so firmly welded together that the suture between them

is not at all visible. The eusternum is a large plate and unlike that of the preceding segments is completely devoid of secondary developed ridges and grooves. Externally a slight depression is formed in the middle of the eusternum which internally presents a similar elevation. It thus divides the eusternum into right and left halves. The bases of the sternal apophysis form a strong median ridge (Fig.70; bmr) with a thick base, and run in antero-posterior direction. The posterior part of the ridge is much broader and extends upto a short distance. The base of the furcae extends anteriorly as a long stout ridge upto about half the length of the eusternum. Its anterior margin is slightly emarginated (Fig.70; aem) and develops from either side a short process (Fig.70; prmr), the anterior tips of which get fused with the eusternum. The eusternal area, anterior to the median ridge of the furcal base, may be called the basisternum (Figs.69, 70, 71, 72 and 73; FS_3), while the area which has become inflected to form the furcal base may be designated as the furcasternum (Figs.69, 70, 71, 72 and 73; FS_3). The basisternum and furcasternum are fused laterally with the anterior laterale and the antecoxal laterale respectively. The sternal apophysis (Figs.69, 70, 71, 72 and 73; Fu_3) runs along the outer wall of the narrow tube of the stink groove and is almost fused with it. Near the posterior margin of the stink fold, it projects out as a flat process pointing antero-posteriorly. The posterior margin of the furcasternum is united by an intersegmental membrane with the

second abdominal sternum (since the first has undergone complete fusion with the metastermum). The endo-sternites like those of the preceding segments is represented only by the furcal arms and the ridges associated with it.

(xi) Musculature of the metathoracic wings

Indirect depressor of the hind wing (Fig.71; No.59).— This is a long thick band of muscle and originates anteriorly from the ventral surface of the semidetached plate (sct_3) of the metascutum and partly from the anterior latero-ventral surface of the mesopostphragma. Posteriorly its fibres are inserted on the laterally developed metathoracic phragma. Malouf named it as 'tergal longitudinal' and describes it as a fan-shaped muscle arising anteriorly from the posterior convex dorsal wall of the mesopostphragma and attached posteriorly to the third phragma.

Flexor of the hind wing (Figs.71 and 73; No.60).— It is a small fan-shaped muscle arising from the anterior dorsal lobe of the episternum. Its fibres are attached on the proximal arm of the third axillary. This is similar to the 'Flexor of hind wing' of the Nezara.

Depressor-extensor of the hind wing (Fig.71; No.61).— This is a long and slender muscle with its fibres originating from the inner apodeme of the subalare sclerite. It is inserted on the proximal coxal rim posterior to the coxal process. It corresponds to the "Depressor of posterior margin of hind wing" of the Nezara

where it is said to arise from the apodeme which is, as a matter of fact, the subalare sclerite.

Dilators of odoriferous sac (Figs.71 and 73; No.62).— It is a long and narrow bundle of muscle fibres running obliquely. It originates from the lateral margin of the third phragma. Distally it bifurcates into two distinct bundles. The first or anterior dilator is attached between the odoriferous sac and the sternal furca, while the second or posterior dilator gets inserted on the rim of the membranous odoriferous sac. It resembles 'Tergo-sterno-furcal' of the Nezara.

(xii) The metathoracic legs (Fig.40c).

These are comparatively much longer in size than the fore- and middle legs. The different segments and sub-segments have become proportionately increased and their structure, the articular points of various joints and the method of articulation is identical to those of the preceding segments. The distal end of the tibia is similar to that of the middle leg.

(xiii) Musculature of the hind legs.

First promotor of coxa (Figs.72 and 74; No.63).— It is divided into two branches. The first of the inner branch (63a) arises from the anterior outer (ventral) wall of the mesopost-phragma while the second or outer branch (63b) has a similar origin and lies posterior to the first branch. The fibres of

both the branches are inserted on a strong apodeme which arises from the distal dorsal surface of the trochantin. Malouf called them as 'tergal promotor' having three branches with the apodeme arising from the anterior coxal rim.

Second promotor of coxa (Figs.72 and 74; No.64).— It is long and slender muscle originating anteriorly from the inflected intersegmental margin of the metapectus. It is inserted on the same apodeme upon which the first promotors are attached. It is similar to 'second sternal promotor' of the Nezara.

Third promotor of coxa (Figs.72 and 74; No.65).— It is a fairly large bundle with its fibres arising from the intersegmental margin of the episternum. Its fibres are inserted on a tendon which ends on the anterior margin of the proximal base of coxa between the trochantinal articulation and the coxal process. It corresponds to the 'third sternal promotor of coxa' of the Nezara.

First remotor of coxa (Figs.73 and 74; No.66).— It is a large muscle having two branches. The inner narrow (No.66a) and the outer broad (No.66b) branches originate from the ventral surface of the second thoracic phragma posterior to the first promotor muscle. Both have a common insertion on a strong tendon which ends on the posterior margin of the proximal coxal base. It is similar to 'tergal remotor' of the Nezara.

Second remotor of coxa (Figs.71, 73 and 74; No.67).— It is the smallest metathoracic leg muscle and arises from the posterior surface of the meta-sternal furca. Its fibres are inserted on the coxal rim posterior to the apodeme of the first remotor muscle. It is equivalent to 'sternal remotor' of the Nezara.

Tergal depressor of trochanter (Figs.72 and 74; No.68).— It is a long and narrow muscle originating from the anterior lateral part of the meta-scutellum. The muscle fibres are attached on an apodeme which ends on the proximal ventral wall of the trochanter.

Pleural depressor of trochanter (Figs.72 and 74; No.69).— It is the largest muscle of the metathorax lying flat along the inner wall of the metapleuron. Its fibres originate from the dorsal margin of the pleuron and are inserted on the same apodeme which gives insertion to its tergal branch.

Both tergal and pleural branches correspond to the "Depressor of trochanter" of the Nezara.

(xiv) Thoracic wings and their sclerites.

There are two pairs of wings (Fig.79) having a remarkable difference in their texture. The fore wings or the hemelytra (Fig.79A) are thickened in their basal halves while the terminal part is membranous. Unlike these, the hind wings (Fig.79B) are entirely membranous. Both pairs of wings lie flat over the

body in repose. The fore wings extend as far posteriorly as the posterior tip of the abdomen, while the hind wings reach upto the middle of sixth abdominal tergum. The latter are kept folded beneath the former.

The fore wings possess four distinct regions. The thickened basal half is divided into an anterior, a mesal and a posterior parts. The first is designated as the embolium (Fig.79A; em) the second (Fig.79A; co) as corium and the third as clavus (Fig.79A; cl). The terminal part is distinguished as the membrane (Fig.79A; mb). The division of the basal half is marked off by the median and anal furrows (Fig.79A; mf and af). The former demarcates the embolium from the corium and the latter separates the corium from the clavus. The basal region of the fore wing is brown with reddish tinge. There are numerous black spots which follow the course of the principal wing veins. The terminal membranous part is creamy white in colour.

The venation of the fore wing (Fig.79A).— It shows a remarkable reduction in the number of veins. The veins of the basal half are fairly distinct while in the membranous terminal part these are more or less suppressed and spring from a transverse basal vein. The costa (C) runs along the anterior margin of the fore wing. Basally the subcosta and the radius (Sc+R) run in a fused condition but approximately in the middle the radius (R) becomes separate leaving the subcosta (Sc) to run below the costal vein. The radius extends ahead, forms a slight curve, then turns

upwards and finally runs beneath the subcosta in the membrane. The media (M) runs above and almost parallel to the anal furrow. It then directs anteriorly, touches the radial vein, turns again downwards and runs in the membrane along the posterior margin of the fore wing. The median furrow runs between the subcosta plus radius and media. The cubitus (Cu) in its normal position runs above the anal furrow, but here it has shifted downwards and runs below the anal furrow in the anterior margin of the clavus. This corresponds to a similar condition present in other Heteropterous insects. The anal (An) runs as a marginal vein along the posterior margin of the fore wing. The only cross vein present is the radio-medial sector (r-m) which connects the radius with the media.

Nomenclature of the cells of fore wings(Fig.79A).

Costellan cell 'a' .— It is bounded posteriorly by the subcosta plus radius and the subcosta and anteriorly by the costal vein.

Subcostellan cell 'b'.— The subcosta forms the anterior margin of this cell, while the radial vein serve as its posterior limit.

Radial cell "c and d".— It is double. The first or the basal radial cell 'c' is bounded anteriorly by the sub-costa plus radius and a part of the radius. The media forms its posterior boundary line, and the radio-medial sector limits its lateral border. The second distal cell 'd' is enclosed with the radius

anteriorly and the medial vein posteriorly.

Medial cell 'e'.— The media forms its anterior boundary line while the cubitus acts as its posterior limit.

Cubital cell 'f'.— The cubitus is its anterior boundary and the anal vein forms its posterior border.

Anal Cell.— The anal cell is not distinct due to the marginal course of the anal vein.

Venation of the hind wings (Fig.79B).— The membranous hind wings are brown with a slight tinge of red colour. When not in use the anal lobe is kept folded beneath the anal furrow. The longitudinal veins are quite prominent while the cross veins have altogether atrophied. The costa (C) in the basal half is almost marginal. It extends forward, first forms an inflection, then an emargination and runs finally as a submarginal vein in the distal half of the wing. The subcosta (Sc) is represented basally with a faint line below the costa. This unlike the former forms mesally first an emargination then an inflection and runs throughout the distal end beneath the costa. The radius (R) is fairly distinct throughout its course. It runs below the subcosta and forms a slight inflection in the middle. The media (M) is feebly developed in its basal half but becomes distinct distally. It bifurcates into two branches M_1 and M_2. Posterior to the media is the cubitus (Cu). It has a short stem and divides into two branches the Cu_1 and Cu_2. The cubitus two runs anteriorly almost parallel

to the anal furrow. The anal is single and runs as a sub-marginal vein within the anal lobe.

Nomenclature of the cells of the hind wings (Fig.79F).

Costellan cell (g).— The costa forms its anterior border while the subcosta serves as its posterior limit.

Subcostellan cell (h).— It is bounded anteriorly by the subcosta and posteriorly by the radius.

Radial cell (i).— The radius serves as its anterior boundary line while the media and part of M_1 forms the posterior margin.

Medial cell.— It is double. The anterior medial cell 'j' is enclosed within the anterior M_1 and posterior M_2 veins, while the posterior medial cell 'k' is bounded anteriorly by media and M_2 and posteriorly by the stem of cubitus and Cu_1.

Cubital cell.— It is also double. The anterior cubital cell 'l' is guarded anteriorly by the cubitus, and posteriorly by the Cu_2, while the stem of Cu and the Cu_2 form the anterior margin of the posterior cubital cell 'm' and the anal limits its posterior boundary.

Anal cell 'n'.— The anal serves as its anterior vein while the posterior margin of the wing forms the posterior border.

The articulation of the wings

The membranous basal area of the wing is known as the

axillary membrance. It brings about the articulation of both pairs of wings to the lateral areas of the corresponding notum of the wing bearing segments. The axillary membrane contains several articular sclerites of varied shape and size which are collectively known as pteralia. These are almost similar in position and function but differ in form in both pairs of wings.

The wings are supported on the thorax by three notable processes. Amongst these, two processes are of the notum while the third belongs to the pleuron. The former are the anterior and posterior notal wing processes and the third is the pleural wing process. The axillary membrane gets thickened in its posterior margin and forms a ligament termed as the 'axillary cord'. It is attached to the posterior notal wing process.

The following articular sclerites are embedded in the axillary membrane of the fore wing.

First axillary sclerite (Figs.75 and 76; 1Ax).— It is longer than broad. Antero-laterally it develops a slight emargination forming a distinct process '1'. Towards the same side it forms another deep emargination which demarcates an anterior narrow part from the posterior broader area. Slightly above this emargination in the anterior narrow part projects a small process 'p_1'. On the side opposite to it, the first axillary forms a slight emargination (Me). The mesal process 'p' of the anterior narrow part of the first axillary articulates with the anterior lobe of the anterior notal wing process, while the posterior process

(p_1) articulates with its posterior lobe. The antero-lateral process 'l' has mad connection with the costal sclerite (humeral plate). The mesal emargination provides an attachment to the second axillary sclerite. The first axillary forms the anterior hinge plate of the wing base.

Second axillary sclerite (Figs.75 and 76: 2Ax).— It is a curved sclerite with a triangular flat upper surface and a highly sclerotized ventral surface. Its flat surface is attached anteriorly to the outer margin of the first axillary sclerite and forms an oblique hinge, while posteriorly it is attached to the median plate. Its ventral sclerotic part forms two knobs. The anterior knob (ak) which is large and black in colour articulates with the pleural wing process. A short cord extends from the small posterior knob (pk) and connects the second axillary with the subalare sclerite. In the sclerotized part of the second axillary is a slight emargination (em) to which is articulated the head of the third axillary. The direct articulation of the second axillary with the pleuron provides a firm support to the wing base from below.

Third axillary sclerite (Figs.75 and 76: 3Ax).— It is an elongated sclerite lying in the posterior part of the axillary membrane. It is bent at an angle beneath the anal furrow and appears to be double (since the articulation between the curved distal and the proximal straight parts has not reached a high degree of sclerotization). Snodgrass (1909) and Malouf (1939)

have shown a similar condition in Belostomidae and Nepare respectively. The anterior end of the distal bent part (r_1) forms the head (h) of the third axillary and is articulated with the second, while the posterior end is associated with the basal plate of anal vein (Fig.76; Abp_1). The proximal straight part (r_2) runs almost parallel to the axillary cord (Fig.76; AxC_1) and articulates with the posterior notal wing process. The flexor muscle of the fore wing is attached on the proximal straight part.

Humeral plate (Fig.76; Hp_1).— It is a small sclerite and internally carries the extension of the costal vein. Its anterior margin runs along the margin of the axillary membrane, while the posterior margin rests upon the first axillary. Its proximal part is closely associated with the costa.

Median plates (Fig.76; M_1 and M_2).— The median plates are bounded above by the humeral plate and partly by the basal part of the costa, and below by the third axillary sclerite. These are divided into two unequal irregularly triangular sclerites by a distinct groove which appears to be the extension of the anal furrow. The anterior plate (M_1) communicates with the base of the media while the posterior (M_2) is associated with the cubitus. These plates are broader distally but taper towards their proximal ends.

Basalare sclerite (Figs.62, 65 and 66; Ba_2).— It is a crescent shaped sclerite lying on the anterior margin of the

episternum above the dorsoventrally flattened arm of the pleural ridge. It has membranous connection with the latter. A large oval plate, the basalare apodeme (Figs.62, 65 and 66; Ba_2Ap) is in direct communication with the basalare by the antero-ventral extension of the pleural arm. The humeral plate rests over the basalare. The basalare apodeme is provided with a flat muscle which originates on the sternal furca.

Subalare sclerite (Figs.66 and 75; Sa_2).— It is almost a triangular sclerite and hangs down freely above the dorsal margin of the epimeron. The anterior tapering process of the subalare has membranous connection with the epimeron, while the posterior process is well placed in the concavity of its supporting plate (Fig.75; $splSa_2$). The latter, which is an elongated sclerite extends posteriorly and articulates with the dorso-lateral projection of postnotum. The upper angle of the subalare receives externally a thin cord (Fig.75; cAx_2) from the posterior process of the second axillary sclerite, while internally it carries a thin apodeme (Fig.75; $ApSa_2$) to which is inserted a long spindle shaped muscle from the mesocoxa.

The following articular sclerites are met with in the hind wings.

First axillary (Figs.77 and 78; 1Ax).— It is a small and more or less crescent shaped sclerite. Its inner lateral margin has a slight convexity while the outer one is deeply concave. Anteriorly it develops two processes, the inner process(i)

of the anterior region is convex while the outer process (o) is almost flat. The inner margin of the first axillary runs along the ridge 'r' of the semi-detached plate of the metanotum, while the outer lies freely in the axillary membrane. Its anterior inner process (i) articulates with the anterior notal wing process while the outer process gives support to the humeral plate. The posterior convex apex of the first axillary articulates with the second axillary sclerite.

Second axillary (Figs.77 and 78; 2Ax).— It is a thick sclerite lying lateral to the first axillary. Its inner margin is almost convex while the outer margin forms mesally a deep emargination (Me). The second axillary develops antero-mesally a pronounced concavity (me), while its posterior end is blunt. Ventrally it carries a sclerotized process (p) which articulate with the pleural wing process. The antero-mesal concavity (me) provides articulation to the convex posterior tip of the first axillary while mesal emargination (Me) is associated with the third axillary. From the posterior end of the second axillary arises a thin cord to which is attached distally the subalare sclerite.

Third axillary (Figs.77 and 78; 3Ax).— It is a long and slender sclerite lying in the posterior part of the axillary membrane. It is sharply bent and forms two arms. The head 'h' of the distal arm 'r' articulates with the second axillary while its posterior part is connected with the basal plate of

the anal vein (Fig.78; Abp_2). The proximal thick arm 'r_2' runs along the axillary cord and articulates with the posterior notal wing process. The proximal arm gives insertion to the flexor muscle of the hind wing.

Humeral plate (Fig.78; HP_2).— It is a fairly large sclerite occupying the anterior most region of the axillary membrane. Its distal end rests over the outer process 'o' of the first axillary while posteriorly it is associated with the costa.

Median plate (Fig.78; MP).— It is an irregular plate lying between the humeral plate and the third axillary sclerite. Unlike that of the fore wing, it is undivided and represents both the medial and cubital elements.

Basalare sclerite (Figs.69 and 72; Ba_3).— It is much reduced and is placed anterior to the pleural wing process. It is in the form of a semi-detached sclerite resting over the dorsal margin of the episternal lobe. No muscle seems to attach on this sclerite.

Subalare sclerite (Figs.69, 71 and 72; Sa_3).— It is a small elongated sclerite with broader anterior and narrow posterior regions. Its inner margin forms mesally a small process 'k' while the outer margin is more or less straight. Externally the process 'k' receives a cord from the second axillary and carries internally an apodeme for the insertion of its muscle. The outer margin of the subalare has membranous connections with the inflected margin of the epimeron.

III. THE ABDOMEN

The abdomen of Lentocorisa varicornis (Figs.80 and 81) is elongated and somewhat cylindrical in shape. It is slightly narrow at the anterior and posterior ends and comparatively broader in the middle. Its terga are almost flat while the sterna are slightly arched. The narrow vertical plates, each of which is placed between the corresponding tergum and sternum of the respective segments, have been named as the pararterga and parasterna. When the insect is fully fed, the dorsal conjunctival membrane becomes expanded and occupies a vertical position on the sides. In females having developing ova, the abdomen gets more expanded in the middle.

The abdomen is composed of eleven segments in male and ten segments in female. The terga and sterna together with the respective components viz. the pararterga and parasterna of certain segments undergo complete fusion with that of the proceeding segments.

The dorsal wall of the abdomen in male consists of ten (1-10) tergal plates, the eleventh being concealed within the tenth. The tergal plates are of various sizes having more or less the same texture. The ventral wall, on the other hand, bears eight (2-9) sternal plates, the first being completely fused with the metathoracic sternum. The dorsal wall in female is composed of nine (1-9) terga, the tenth lying within the ninth. The ventral

wall consists of six (2-7) sterna, the remaining two, i.e. the eighth and ninth have become modified to form the genital structures. The dorsal and the ventral walls are separated from one another by the intervention of the laterally placed paraterga and parasterna. The sterna are divided into three pieces by a thin sutural line. The narrow lateral plates lying on either side of the central sternal plate are the parasterna. The spiracles are situated on the parasterna from second to seventh segments both in male and female. The seventh spiracle of female has made access to the eighth paratergum due the fact that the eighth sternum has become very narrow and membranous.

There is much controversy regarding the abdominal Sclerites, especially the pleurites, in Hemiptera. Heymons(1899) on the basis of the embryological study considers that the intervening plate between the terga and sterna is formed partly from the terga and partly from the paraterga and therefore, is of the opinion that "special sclerites" are absent in Hemipterous abdomen. Hanson (1902), Deoring (1922) and Malouf (1932) regarded the broad band lying between the terga and sterna as 'pleura'. Comstock (1925), Imms (1925) and Quadri (1950) have almost a common view that the pleura are membranous and do not occur as distinct sclerites. Hamilton (1931) in Nepa and Snodgrass (1933) in Pentacora and Anasa have shown the presence of paraterga and parasterna.

The present writer made a thorough study of the abdominal sclerites of nymphs as well as adults of Leptocerisa but could not find any distinct pleural plate. In the nymphs, the terga arch over to meet the sterna and therefore no proper differentiation of the paraterga and parasterna exists. The complete differentiation takes place only after the final moult when the paraterga and parasterna occupy a lateral position and are likely to be confused as pleural plates.

The abdomen has undergone certain morphological changes at different places. These regions, therefore, can be conveniently designated as pregenital, genital and post-genital.

1. The pre-genital region.— It is composed of seven (1-7) segments both in male and female. Tower(1912) in Anasa tristis has recognized the sixth segment as the last pregenital segment. The complete fusion of the first tergum with the second as well as the absence of the first sternum led him to make such an error. Snodgrass (1933) has shown the presence of seven segments in the same insect. The pregenital region is the longest and broadest part of the abdomen and encloses the chief viscera of the insect under review.

(i) The pre-genital terga.— It consists of one to seven terga, the first two (Figs.80, 84 and 87; I & II T) being firmly united with each other. The first tergum is broader than long with slightly emarginated anterior margin (Figs.80,81,84, 87 and 90; emIT). The antero-lateral margin is angular(Figs.80,

81, 84, 87 and 90; almIT). The antecostal suture is indistinct though the tergum bears anteriorly an almost marginal antecostal ridge (Figs.81, 87 and 90; Ac_1). The actrotergite (Figs.80 and 84; atg_1) like-wise, is represented only by a marginal rim. The second tergum like the first is broader than long. Its complete fusion with the first tergum has brought about the total obliteration of the inter-segmental membrane. The antecostal ridge (Fig.87; Ac_2) is fairly developed and represents externally the antecostal suture (Figs. 80 and 84; acs). The third tergum is a rectangular plate and is equal in size to the combined first and second terga. It is slightly broader than long. The conjunctival membrane between the second and third terga is well developed. The antecostal elements are similar to those of the preceding segments. Its posterior margin is fused with the anterior margin of the fourth tergum. The fourth, fifth, sixth and seventh terga are fused with one another and therefore the separate identity of antecostal ridges and acrotergites is lacking. The fourth, fifth and sixth terga are longer than broad and comparatively larger than the previous ones.

The paratergum of the first segment is absent while those of second to seventh segments (Figs. 80, 82, 84, 87, 88 and 89; $p^T 2-7$) are well developed. These lie all along the lateral sides of the pregenital region.

(ii) The pre-genital sterna.— It is composed of six (2-7) sterna which are almost similar in structure in both male and female. The first sternum has undergone complete fusion with

the metasternum and therefore the second sternum (Figs. 81 and 90; II Stn) represents the first ventral sclerite and is about twice as broad as its length. The anterior margin is produced mesally to form a small lobe (Figs.81 and 90; aml II Stn) while the antero-lateral margin is rounded. The antecostal suture is feebly marked off while the marginal antecostal ridge (Fig.90; ac_2) is well developed. The acrosternite (Fig.81; ATG_2) is marginal. Its posterior margin is slightly curved and is fused with the anterior margin of the third sternum. The latter is a rectangular plate about twice in size to the second sternum. Its posterior margin is also curved and is fused with the anterior margin of the fourth sternum. The latter is larger than the third. The antecostal ridge and the acrotergite are insignificant in third and fourth sterna. The fifth sternum attains the maximum size. The antecostal suture (Figs.85 and 91; Acs_5) is distinct and develops internally the submarginal antecostal ridge (Figs.85 and 91; ac_5). The latter sets off anteriorly a fairly large acrosternite (Figs.85 and 91; ATG_5). The sixth sternum is similar in structure and almost equal in size to the fifth one. The seventh sternum resembles the fifth and sixth in all respect except that its posterior margin in male (Fig.83; pem VII Stn) is deeply emarginated while in female it forms the subgenital plate and is produced mesally into a small lobe (Fig.81; pml VII Stn). The inter-sternal membrane is well developed between the fourth and fifth, fifth and sixth and sixth and seventh sterna.

Snodgrass (1933) in Anasa tristis describes the posterior margin of the seventh sternum as deeply emarginated and bearing mesally a pair of small lobes at the base of which is a transverse groove. In Leptocorisa the present writer could find neither the paired lobes nor the transverse groove.

A feebly developed suture which divides the sterna laterally, sets off on either side the parasternal plates (Figs.81, 83, 85, 90 and 91; pStn). Each parasternite corresponds to its respective sterna and bears almost in the middle, the abdominal spiracle (Figs. 81, 83, 85, 90 and 91; sp).

2. The genital region.— It consists of the ninth segment in male and eighth and ninth segments in female. The eighth segment in male is much reduced and though it is in close association with the ninth segment, it has nothing to do with the mating activities of the male. The adaptations to the acts of copulation and oviposition render these segments to undergo structural modifications.

(i) The genital terga.— The eighth tergum of male (Figs.82 and 88; VIII T) is a narrow strap-shaped plate, broader at the lateral sides and narrow in the middle. It extends downwards to meet the large sternal plate. The ninth tergum, on the other hand, in male (Figs.82 and 88; IX T) is a fairly large dorsal plate. It is slightly broader than long with rounded antero-lateral and postero-lateral angles. Its anterior margin

is almost straight but the posterior margin develops mesally a deep emargination (Fig.82; pe IX T) forming a prominents cup-shaped cavity. Within the latter is placed the tubular proctiger (Fig.82; Prt_g). This emargenation of ninth tergum gives it a horse-shoe-appearance with arms directing posteriorly. The inter-segmental membrane between the eighth and ninth segments is fairly large and helps the male to protrude the abdomen to a longer distance during copulation.

The eighth tergum of female (Figs.80 and 89; VIII T) is similar to the pregenital terga except that it is broad anteriorly and narrows down towards the posterior end. Also, the paratergal plate (Fig.81; pT_g) extends more ventrally so as to assume the position of the parasternal plate which is absent in eighth segment. The seventh abdominal spiracle therefore, instead of being placed on the parasternal plate, lies in the paratergum.

The ninth tergum of female (Fig.80; IX T) resembles the eighth one though it is much smaller in size. It bends dorso-laterally at a sharp angle and covers a part of the lateral sides. Its antero-ventral margin develops a small process (Figs.94 and 95; n) to which is attached the elongated plate of the inner ramus of first vavula. The antero-ventral angle forms a small articular knob (Figs.94, 95 and 96; p) which provides articulation to the second valvifer. The spiracle is absent.

(ii) <u>The genital sterna</u>.— The eighth sternum of male (Fig.83: VIII Stn) is fairly a large plate lying below the ninth

one. The latter (Fig.83; IX Stn) is also very large and gives support to the phallic organs.

The sternum of the eighth segment is very much reduced in female and is represented by a membranous region which lies anterior to the genital chamber between the bases of the first valvifers and valvulae. The ninth sternum is also reduced and appears as a membranous area between the second valvifers.

3. The post-genital region (Figs.80,81,82 and 86).— The tenth and eleventh segment in male and the tenth in female constitute the post-genital region.

The two post-genital segments of male unite together to form a tubular structure, the proctiger (Fig.82; prtg). Its dorsal wall is in direct communication with the ventral wall. The anal vestibule (Figs.86 and 93) lies concealed within the distal end of the proctiger. It carries two distinct plates; the dorsal being the 'supra-anal plate' (Figs.86 and 93; Sap) while the ventral is known as the sub-anal plate (Fig.86; sap). The rectal wall is attached to the anterior (inner) margin (Figs.86 and 93; amvst) of the anal vestibule while the posterior (outer) (Figs.86 and 93; pmvst) represents the anus.

The tenth segment of female appears as a short tubular proctiger (Figs. 80 and 81; prtg). Tower (1913) in Anasa tristis erronously regarded it as the ninth segment. The anal vestibule

is similar to that of the male and is concealed beneath the proximal end of the tenth segment.

4. The musculature of the abdomen.— The muscles of the abdomen conform to those of other hemipterous insects. There are four groups of muscles namely, the inter-tergal, inter-sternal, tergo-sternal and spiracular muscles. The latter group of muscles will be described in connection with the respiratory system.

The study of the abdominal muscles reveals that those segments which have undergone complete fusion do not possess the inter-tergal and inter-sternal muscles for the simple reason that their movements are co-ordinated with the segments bearing the muscles. The tergo-sternal muscles are invariably present nearly in all the pregenital segments.

(i) The inter-tergal muscles.— These are also known as dorsal muscles and run longitudinally between the intersegmental folds of the two successive terga. These muscles are present in the first, second, seventh and eighth segments of both male and female. The inter-tergal muscle may be arranged in one or two rows. The inner row constitutes those muscles which lie near the median line of the terga and are termed as "median longitudinals". The lateral longitudinals, lying towards the lateral sides, form the outer row. The first and second segments include both the outer (Fig.87; Nos.70 and 72) and inner rows (Fig.87; Nos.71 and 73) while the seventh and eighth segments possess only the outer row of muscles (Figs.88 and 89; Nos.74 and 75).

The muscles of the first and second segments are similar in origin and insertion. The fibres of the median and lateral inter-tergal muscles run longitudinally almost parallel to each other and originate from the antecostal ridge of one tergum to end on the anterior margin of the tergum following it.

The long and slender lateral inter-tergal muscles of the seventh and eighth segments run longitudinally and arise from the antecosta of the seventh and eighth terga respectively. Its fibres are inserted on the respective anterior margins of the eight and ninth terga.

The third, fourth, fifth and sixth terga are fused with one another and do not possess the inter-tergal muscles.

(ii) The inter-sternal muscles.— These are also termed as the ventral longitudinal muscles and unlike those of the inter-tergal muscles, run between the intersegmental folds of the two successive sterna. There is only one row of inter-sternal muscles in second, fifth, sixth and seventh segments of male. The ventral muscles in female are confined only in second, fifth and sixth segments.

The intersternal muscles (Figs.90 and 91; Nos.76 and 77) of the above mentioned segments are typical. These originate from the antecostal ridge of a sternum and get inserted on the anterior margin of the sternum following it.

The complete fusion of the first sternum with the meta-sternum has brought about the total obliteration of the former. The third and fourth sterna are also firmly welded together. The inter-sternal muscles are, therefore, absent in these segments.

(iii) The tergo-sternal muscles.— There are seven pairs (2-8) of tergo-sternal muscles in male and six pairs (2-7) in female. The muscles of the different segments except the second are almost equal in size and resemble in their origin and insertion.

The tergo-sternal muscles of the second segment are very small and originate from whole of the lateral margin of the second sternum. Its fibres are attached on the second tergum and few of its fibres also end on the posterior half of the first tergum.

The tergo-sternal muscles (Fig.92; No.78) of other segments are typical. These are stout and flat muscle arising from the lateral sides of the central sternal plate. After running ventro-dorsally, its fibres end on the lateral sides of the corresponding tergum.

The abductor of supra-anal plate.— This (Fig.93; No.79) is a very small and thin muscle originating from the antero-dorsal wall (Fig.93; adw) of the proctiger. After running in antero-posterior direction its fibres become inserted on the supra-anal plate. Its contraction raises the supra-anal plate which opens the anal vestibule through which the faeces of the insect escape outside. This muscle corresponds to muscle No.124 of stenobracon deesai, (Alam 1953).

5. The female genitalia

The female genitalia (Figs.94, 95 and 96) of Leptocorisa varicornis is covered dorso-laterally by the eighth and ninth tergal plates (Figs.94, 95 and 96; VIII and IX T) while ventrally the seventh sternum (Figs.81 and 95; VII Stn) which forms the sub-genital plate, protects only a part of the anterior region. The ovipositor is fairly developed and is kept concealed by the first valvifers. When viewed from the ventral side only the distal part of the second valvulae (Fig.81; 2 VI) is visible. The ovipositor bears two pairs of lobes which can be best seen if the valvifers are set apart. The genital chamber lies between the bases of the first valvulae. The genitalia consists of (i) a pair of first valvifers, (ii) a pair of first valvulae, (iii) a pair of second valvifers and (iv) a pair of second valvulae. Unlike other hemipterous insects, the third valvulae is totally absent.

(i) The first valvifer (Figs.81, 94 and 95; 1Vlf).— It is a large triangular plate having almost a pleural position. The anterior margin (Figs.81, 94 and 95; amiVlf)has membranous connections with the posterior margin of the seventh sternum, while the posterior margin (Figs.81, 94 and 95; pmiVlf) extends so far as to cover the whole of the second valvifer. Its dorsal margin (Figs.94 and 95; dmiVlf) is nearly straight and is loosly connected with the ventral margin of the eighth and ninth terga. The ventral margin (Figs.94 and 95; vmiVlf) is slightly irregular

and comes to lie at the base of the ovipositor. The antero-dorsal angle of the first valvifer carries a small well defined apodeme (Figs.94 and 95; ApIVlf) to which are attached its levator and depressor muscles. The outer ramus of the first valvula, as will be shown later, is attached to the anterior end of the first valvifer. Crampton (1929) regarded the first valvifer as "Basivalvula". Snodgrass (1933) corrects this mistake for reasons already given by him.

(ii) <u>The first valvula</u> (Figs.94 and 95; lVl).— It is a fairly developed plate about two-third in length of the first valvifer. It is broader at the base and tapers abruptly towards its distal end. Its dorsal margin (Figs.94 and 95; dmlVl) is deeply concave while the ventral margin (Figs.94 and 95; vmlVl) is convex. The course followed by the dorsal and ventral margins as well as the abrupt tapering give the first valvula an appearance of a birds head. Snodgrass (1933) in Anasa tristis has shown the presence of a plate on the outer surface of the first valvula, and bearing short spines at its distal end. The present writer could not find any such plate in Lentocorisa. The dorsal surface of the valvula carries a pair of sclerotized ridges which run almost parallel to each other. These marginal (Figs.94 and 95;mr) and sub-marginal (Figs.94 and 95; smr_1) ridges form between them a shallow groove (Figs.94 and 95; gr) into which glides the corresponding ridge on the ventral surface of the second valvula. The valvula develops at its proximal end two branches or rami.

The inner ramus (Figs.94 and 95; irlVl), formed by the prolongation of the dorsal angle, is produced upwards and gets connected with an elongated narrow plate (Figs.94 and 95; m) which runs parallel to the ventral margin of ninth tergum. This plate becomes attached to a small process (Figs.94 and 95; n) from the antero-ventral angle of the ninth tergum. The outer ramus (Figs.94 and 95; orlVl), on the other hand, extends from the antero-ventral angle of the valvula to get attached to the anterior end of the first valvifer. A small dark coloured and sclerotized oblong plate, the basivalvula (Figs.94 and 95; BsVl) lies at the base of the first valvula between the two rami. Crampton (1929) and Snodgrass (1933) are silent regarding this sclerite.

(iii) The second valvifer (Figs.94 and 96; 2Vlf).— It is an elongated sclerotized plate lying on the lateral side of the ninth tergum. It is normally kept concealed beneath the first valvifer. The dorsal and ventral margins of the second valvifer are almost straight. The anterior margin has membranous connections with the proximal end of the second valvula, while the distal end is quite free and presents a truncate edge. The dorsal margin near its middle develops a small concavity (Figs.94 and 96; q). The ninth tergum, on the other hand, forms at the antero-ventral angle an articular knob (Figs.94 and 96; p) which provides articulation to the second valvifer. The muscles of the second valvifer are inserted on the anterior and posterior end of the dorsal wall in such a manner that each muscle lies

on either side of the articular point.

(iv) The second valvula (Figs.94 and 96; 2Vl).— It is longer than broad and less sclerotized than the first valvula. The second valvulae of the corresponding sides have become united with each other throughout their length except in the distal end (Fig.81; 2Vl) where they appear as free lobe-like structures. The proximal base is membranous and is attached to the antero-ventral margin of the second valvifer. The ventral wall of the second valvula towards its dorsal margin develops a sub-marginal ridge (Figs.94 and 96; smr_2) which fits into the corresponding groove present on the dorsal wall of the first valvula (Figs.94 and 95; gr).

The third valvula is absent in L. varicornis.

6. The musculature of the female genitalia

The following six pairs of muscles are associated with the working of the ovipositor.

1. The principal depressor of first valvifer (Fig.95;No.80).- It is a broad muscle originating laterally from the seventh sternum. Its fibres take up a convergent course and get inserted on the lateral side of the dorsal apodeme of first valvifer.

2. The accessory depressor of first valvifer (Fig.95;No.81).- It is a small muscle with its fibres originating from the inner surface of the first valvifer. It runs in antero-posterior direction to get inserted at the base of the elongated narrow plate

of inner ramus of first valvula.

3. The first (principal) levator of first valvifer (Fig.95; No.82).— It is a long and slender bundle with its fibres arising from the anterior margin of the eighth tergum. It runs obliquely in dorso-ventral direction and occupies nearly a tergo-pleural position. It is attached ventrally on the dorsal apodeme of the first valvifer.

4. The second (accessory) levator of first valvifer (Fig.95; No.83).— It is comparatively smaller than the first levator and originates from the lower portion of the anterior margin of eighth tergum. It runs postero-anteriorly to end anteriorly on the dorsal apodeme of first valvifer.

These two levator muscles are antagonistic to the depressor muscles of the first valvifer.

5. The anterior muscle of second valvifer (Fig.96; No.84).— It is a long strap-shaped muscle originating from the antero-dorsal margin of the ninth tergum. It runs obliquely and ends on the anterior end of the second valvifer. Its contraction retracts the second valvula, and therefore functionally it can be called "Retractor of second valvula".

6. The posterior muscle of second valvifer (Fig.96; No.85).- It is the largest muscle of the female genitalia. Its fibres arise dorsally from the ninth tergum and run in dorso-ventral direction. It is inserted over a large area on the posterior end of the second valvifer. It is antagonistic to the anterior muscle

and since it protracts the second valvula, it can be termed as "Protractor of second valvula".

7. The male genitalia

The male genitalia of Leptocorisa varicornis is placed mesally on the ninth abdominal sternum which forms the sub-genital plate. The eighth sternum, on the other hand, extends posteriorly a short distance beneath the ninth sternum and thus becomes an external plate'. According to Pruthi (1925) the eighth sternum is either missing or very small while Ekblom (1926) regarded it to be frequently missing in Heteroptera. The eighth and ninth sterna have been termed as hypandrium and pygophor respectively by Myers (1928). The principal genital organs, commonly known as phallic organs, lie mesally on the ninth sternum while the accessory structures i.e. periphallic organs are situated at its periphery.

1. The phallic organs.— These include the principal genital organs which play an important role in the act of copulation. The median intromittent apparatus is a conical structure, the phallus which is differentiated into two distinct parts; a proximal sclerotized phallobase and a distal membranous aedeagus. Pruthi (1925) called these proximal and distal parts as phallosoma and endosoma respectively.

(i) The phallobase (Figs.97, 98, 99 and 100; Phb).— It is

the most important part of the male genitalia and forms the proximal (basal) part of the phallus. It includes various essential structures such as a pair of basal plates, a pair of oblong plates, an unpaired dorsal bar and a pair of lateral valve-like sclerites, the parameres. The phallobase is a rounded structure and upon the basis of the degree of sclerotization can be distinguished into two parts. The proximal half (Figs.97 and 98; prPhb) is feebly sclerotized and received mid-ventrally a pair of convergent basal apodemes (Figs.97 and 98; ap_2) which provide insertion to the accessory retractor muscles. Besides the posterior wall of the proximal phallobase is pierced in the centre by ejaculatory duct (Figs.97, 98, 99 and 100; Dej). The distal half attains highest amount of sclerotization. It extends anteriorly and gradually narrows down distally to form a fold (Figs.97 and 98; bfPhb) at the base of the virga (sclerotized part of the ejaculatory duct). Hamilton (1931) regarded the phallosoma (phallobase) to be entirely membranous in Nepa. A sclerotized elongated basal plate (Figs.97, 98, 99 and 100; Bpl) extends on either sides from the mid-ventral part of the phallobase. It runs transversely for a very short distance and then gradually curves upwards along the anterior margin of the ninth sternum. The basal plate is broad at the base and supports the phallobase from below. Its distal margin has membranous connection with the ventral half of the parameral valves. The distal region of the basal plate develops on its anterior margin an inner and an outer lobe-like structures. An apodeme (Figs.97, 98, 99 and 100; ap_1) proceeds

dorsally from the inner lobe (Figs.97, 98, 99 and 100; ilBpl) and ends on the under side of an oblong plate (Figs.97, 98, 99 and 100; obpl). The latter occupies almost a horizental position and furnishes an increased surface for the insertion of the extensor muscle. The outer lobes (Figs.97, 98, 99 and 100; olBpl) of the corresponding sides are connected together by a semi-sclerotic transverse rod (Figs.97, 98, 99 and 100; DTr). The posterior margin of the basal plate provides attachment to the powerful retractor muscle. The dorsal transverse rod has made membranous connection with the dorsal half of the valvular scleri-tes. It also aids in effective meovements of the basal plates. The ventro-lateral basal plate and the dorsal transverse bar correspond to the 'upwardsly curved rod' and the 'dorsal cross-bar' of Nepa respectively described by Hamilton (1931). Heymons (1899) observed these dorsal and ventral structures as pertaining to the ninth tergum and sternum respectively while Berlese (1909) regar-ded them to be 'chitinous processes of the ninth sternite'. Pruthi (1925) described these rods as prolongation of the basal plates (appendages) of the membranous phallosoma. The present writer considers that not only the ventro-lateral basal plates and the dorsal transverse rod but also the oblong plates and the parameral valves are component structures of the phallobase itself since these are inter-related with each other. Further evidence in its favour is deduced by the phallic muscles which are inserted on some of these processes of the phallobase (the aedeagal muscles being absent in Leptocorisa).

A pair of lateral value-like sclerites (Figs.97, 98, 99 and 100; PrV), which cover externally almost all the dorso-lateral and ventro-lateral surface of the phallus, extend anteriorly from the dorsal transverse rod and the ventro-lateral basal plates of the phallobase. These sclerites unite mid-dorsally and mid-ventrally. The "outer plates" of Nepa described by Hamilton (1931) correspond to these sclerites. Quadri (1949) has also described similar structures (parameral valves) in Heteroptera and regarded the whole outer portion as phallus. When the origin and fusion of these sclerites are taken into consideration, their association with the phallobase becomes evident. The present writer therefore prefers to retain Quadri's term 'parameral valves' for the lateral sclerites since these prove true to the requirement of the parameres.

(ii) The aedeagus (Figs.97 and 98; Aed).— The completely membranous aedeagus occupies the distal part of the phallus and is surrounded externally by the parameral valves. The dorsal and ventral walls of the aedeagus are armed with sclerotized processes. A pair of small truncated processes (Fig.98; dpr) are imbedded on the dorsal membranous aedeagus while two pairs of processes lie on its wall. Of these, the distal pair (Fig.98; avpr) is long and slender and the second pair (Fig.98; mvr) lies almost in the middle. The latter pair is of unequal size and the two processes are closely applied to each other. These processes correspond to the "struts and styliform appendages" of Nepa. Pruthi (1925) and

Hamilton (1931) considered these to constitute the aedeagus. The part played by these processes during copulation is not known.

A pair of highly sclerotized short processes arise from the lateral sides of the distal half of the phallobase where the latter forms a fold at the base of the aedeagus. These aedeagal apodemes (Figs.97 and 98; Aedap) extend in antero-dorsal direction. Each apodeme is slightly curved with inner concave and outer convex margins. Hamilton (1931) did not give any account of these processes but from the diagrams it appears that the said structures are present in Nepa also. In the opinion of the present writer the aedeagal apodemes of Leptocorisa varicornis correspond to the "lever rod of penis" of Nepa.

The ejaculatory duct (Figs.97, 98, 99 and 100; Dej) becomes a highly sclerotized tube where the phallobase forms a fold at its distal most region. This apical part of the ejaculatory duct (Figs.97 and 98; Vr) has been termed as 'virga' by Quadri (1949). The virga is coiled at the base and extends distally as a curved tube. It is the principal intromittent organ of Leptocorisa.

2. The periphallic organs.— These comprise a pair of movable appendages and an unpaired immovable process which arise peripherally and articulate with the inflected wall of the ninth sternum. These periphallic organs are situated at a far off distance from the base of the intromittent organ.

The paired movable appendages (Figs.97 and 101; Clp) are situated on either side of the phallus and are commonly known as claspers or harpagones (styli) since these help in grasping the female during copulation. Each harpagone takes its origin from the inflected wall of the ninth sternum and therefore lies partly concealed within the genital chamber. The proximal half of the harpagone develops ventrally a broad base (Figs.97 and 101; bolp) for the attachment of the muscles. The distal half, on the other hand, is bent into a curve forming a sickle-shaped structure. The terminal part of the distal half also forms a small knob (Figs.97 and 101; kb). It is probable that during copulation the concave surfaces of the claspers are closely applied to the sides of the body of female and the two knobs of the corresponding claspers meet dorsally to give a firm hold to the female.

The unpaired periphallic process (Fig.97; mPPh) is immovable and originates mesally from the inflected wall of the ninth sternum. Its distal margin develops three lobes which are almost of equal size. It is not provided with muscles and its function is obscure.

8. Musculature of the male genitalia

In Leptocorisa varicornis the parameral values and the aedeagus are not provided with independent muscles. The median intromittent organ, therefore, is moved as a whole by three pairs

of phallic muscles namely the extensors, the principal and accessory retractors. The harpagones are provided with muscles of their own.

(i) Extensor muscle of the phallus (Figs.99 and 100; No.86).— It is a large and thick fan-shaped muscle and originates from the lateral side of the ninth tergum. Its fibres converge to end on the dorsal surface of the large oblong plate of the phallobase. Its contraction protrudes the whole intromittent organ.

(ii) Principal retractor muscle of the phallus (Figs.99 and 100; No.87 a).— It is also a large muscle and originates from the inner latero-ventral surface of inflected anterior margin of the ninth sternum. The fibres of this bundle get inserted on the posterior surface of latero-ventral basal plate of the phallobase. This muscle is antagonistic to the first and retracts the phallus.

(iii) Accessory retractor muscle of the phallus (Figs.99 and 100; No. 87 b).— It is comparatively much smaller than the preceding ones. It arises from the whole inner ventral surface of the inflected anterior margin of the ninth sternum and gets attached on the basal apodeme (ap_9) which ends mid-ventrally on the proximal part of the phallobase. It is also antagonistic to the "Extensor muscle" and indirectly retracts the intromittent apparatus.

(iv) Adductor muscle of the harpagone (Fig.101; No.88).— It is a large but thin fan-shaped muscle and originates from the latero-ventral part of the ninth sternum. Its fibres converge to end on the broad base (bClp) of the harpagone. The contraction of the muscles draw the harpagones towards one another. When the muscle relax, the harpagones of the corresponding sides draw back and assume their normal position.

INTERNAL ANATOMY including HISTOLOGY

OF

LEPTOCORISA VARICORNIS FABR.

IV INTERNAL ANATOMY.

1. The Digestive System

The digestive tract or the alimentary canal of Leptocorisa varicornis is divided into three main regions viz. the stomodaeum, mesenteron and proctodaeum. The openings of the stomodaeum into mesenteron and the latter's into proctodaeum are guarded by circular folds forming respective cardiac and pyloric valves. Other features of morphological interest are the division of the mesenteron into four regions, the formation of the caecal diverticula in the fourth stomach and opening of malpighian tubules in the anterior end of the proctodaeum.

The stomodaeum.— It consists of the pharynx, crop, and proventriculus. The oesophagus is an undifferentiated tube lying between the pharynx and crop. The functional mouth or the food maetus lies anterior to the sucking pump which represents the preoral ciberium of Orthopteroid insects. The posterior opening of the sucking pump into pharynx is the true mouth.

(i) The pharynx (Figs.30,31,33,34,35 and 119; Ph_1 and Ph_2).— It extends antero-posteriorly from the sucking pump as a long and slender tube. It is divided into an anterior precerebral and a posterior postcerebral pharynx. The anterior pharynx lies between the brain and the oesophageal ganglion anterior to the nerve connectives while the posterior pharynx occupies a position posterior to the nerve connectives. The anterior and posterior pharynx

can be differentiated from one another by the origin and insertion of the dilator muscles (already described in head region) which according to Snodgrass (1935) are a better guide for the identification of the two regions. The pharynx leads posteriorly into the oesophagus.

(ii) The oesophagus (Fig.102; Oe).— It is followed by the pharynx and extends as a straight tube from the foramen magnum to the posterior part of the metathorax. Its narrow anterior part gradually widens out posteriorly into the crop(Fig.102;Cr).

The histology of the oesophagus follows the general plan and conforms to that of other insects. The epithelium which forms the inner lining of the oesophagus is produced into folds which project into the lumen. The epithelium (Fig.103; Epth) is composed of cubical cells within which the nuclei are regularly arranged. The inner surface of the epithelium is lined by a thin layer, the intima (Fig.103; In). The latter forms the inner most layer and develops folds which follow almost the same course of the epithelial foldings. The outer surface of the intima is covered with fine hairs (Fig.103; h) which are thus in close association with the lumen. The longitudinal muscle layer (Fig.103;ImI). is placed external to the epithelial layer, while the layer of the circular muscles (Fig.103; cmI) forms the outer most coat of the oesophagus.

(iii) The crop (Fig.102; Cr).— It may be called the posterior enlargement of the oesophagus and extends from the anterior region of the first to the posterior part of the fifth abdominal

segment. When the food contents are scanty, the crop develops externally certain longitudinal and transverse wrinkles which are in no way associated with the internal epithelial foldings.

The histology of the crop is almost similar to that of the oesphagus. The inner most lining of the intima is slightly thicker and the epithelial foldings are smaller. In the fully stretched crop, the epithelial layer and the intima are almost regular.

Dufour (1833) and Glasgow (1914) have erroneously, for reasons given by Malouf (1933), named the crop as 'premiere poche du ventricule chylifique on estomae' and 'first stomach' respectively. Malouf (1933) in Nezara has shown that the inner layer of muscle in the oesophagus and crop is that of the circular muscle while the longitudinal muscles lie external to it. Further he claims the outer most layer to be a nucleated peritoneal layer. The histological study of the same regions of the stomodaeum of Leptocorisa varicornis shows the reverse arrangement of muscle layers. Moreover, the present writer could not find any peritoneal layer covering the stomodaeum.

(iv) <u>The proventriculus</u> (Fig.102; Pvent).— It represents the posterior most region of the stomodaeum and appears as a small tube lying between the crop and the first ventriculus. The proventricular armature of the chewing insects is totally lacking due to the different nature of food material.

The histology of the proventriculus (Fig.104) resembles to those of the oesophagus and crop. The cardiac valve (Fig.104; CVlv) is formed by the posterior wall of the proventriculus and hangs down into the lumen of the first stomach as a circular fold. Each of the two lamellae of the cardiac valve are covered with intima (Fig.104; In) which is beset with numerous short fine hairs. Malouf (1933) is silent regarding the proventriculus and the cardiac valve.

The mesenteron (Fig.102).— It is also known as the stomach or ventriculus. It is a highly coiled tube extending posteriorly from the proventriculus to the middle of the seventh segment. The ventriculus of Leptocorisa varicornis, like those of other heteropterous insects, shows four remarkable regions, each differing from the other in length and diameter. The first stomach (Fig.102; $Vent_1$) which is almost of uniform diameter extends a short distance posteriorly and then turn anteriorly. It twists to run ventrally upto the middle of the seventh Segment where it swells up to form a sac-like second stomach (Fig.102; $Vent_2$). The size of the latter varies in different individuals and directly depends upon the amount of food contents. The second stomach runs anteriorly and abruptly tapers out into a short slender tube of uniform cross-section. This is the third stomach (Fig.102: $Vent_3$) which extends to form a highly coiled fourth stomach (Fig.102;$Vent_4$). The latter is provided with four longitudinal rows of caecal diverticula. Dufour (1833) named the first, second and third stomach as 'portion filiforme'; 'second poche gastrique' and col de cette

poche' respectively. He further showed four separate cord-like longitudinal rows of caeca in the last part of the mesenteron. Glasgow (1914), on the other hand, called the first stomach as second stomach; the second as third stomach and combined the third and fourth into fourth stomach.

The histology of the ventriculus is almost similar in all the regions except the fourth stomach where the caeca have become developed. The epithelial layer develops many longitudinal folds or villi. The columnar cells are fairly large and form the major part of the epithelial wall (Fig.105; Epth). Their nuclei lie almost in the middle and are laiden with much granular substance. Few small cells which mostly occur in groups, are located between the bases of the columnar cells. The large columnar cells projects into the lumen of the stomach and are associated with the processes of secretion and absorption, while the smaller cells take part in the replacement of worn out columnar cells. The two types of cells referred to above perform different functions and therefore upon the basis of nature of work, the columnar cells may be called 'digestive cells' (Fig.105; dgc) and the small basal cells, the 'regenerative cells' (Fig.105; rgc). Both the digestive and regenerative cells rest upon a thin basement membrane (Fig.105; Bmb). The digestive cells are almost of uniform structure and show various stages of disintegration at different places in the stomach. The internal wall of the columnar cells is marked off as a marginal layer having numerous fine lines lying perpendicular to its surface. This marginal epithelial layer is known as 'striated border' (Fig.105; Sb) and has essentially the same structure of

alternate dark and clear lines through which the digestive juices of the cells pass into the lumen. The secretion of the stomach is merocrine type where the columnar cells of the epithelial layer swell up and later on constrict to separate off ultimately as a non-nucleated globules (Fig.105; b). The regenerative cells mostly occur in small groups (nidi) at the base of the epithelial layer, the neighbouring columnar cells of which surround them completely. The nuclei are small with less granule. The regenerative cells, as mentioned above, are responsible for the replacement of the disintegrated digestive cells of the epithelium. The peritrophic membrane is absent. The muscular sheath is feebly developed and the arrangement of the muscular layers is just the reverse to that of stomodaeum. The longitudinal muscles (Fig.105; lml) form the outer most layer of the stomach while the circular muscles (Fig.105; cml) lie internal to it below the basement membrane. Malouf (1933) has wrongly described the longitudinal muscles as lying internal to circular muscle layer. Moreover, the present writer could not find any outermost peritoneal layer in Leptocorisa varicornis as claimed by Malouf in Nezara.

Four longitudinal rows of caeca traverse the whole length of the fourth ventriculus. In cross section the caeca appear as flat discs and are composed of non-nucleated matrix. The caeca lack the epithelial lining. According to Glasgow (1914) 'food mass in the process of digestion apparently never gets beyond the third stomach'. The caeca therefore perform a function other than digestion. Glasgow further demonstrates that the

bacteria are hereditary and appear early in the digestive canal of the embryo. He further states that "these normal bacteria appear not only to inhibit the developing foreign bacteria but to exclude them altogether".

The proctodaeum (Figs.102 and 106).— It is the last part of the alimentary canal and presents two sub-divisions; the short anterior and the long posterior intestines. The anterior intestine is externally demarcated from the posterior intestine by a marked constriction.

(i) The anterior intestine (Figs.102 and 106; Int).— It is a short and narrow tube of uniform cross-section. It is separated from the fourth stomach by a well-defined constriction (Fig.106;g). The opening from the fourth ventriculus into the anterior intestine is guarded by an internal circular fold which is formed by the elongated columnar cells of the ventricular epithelium. These cells project into the lumen from the posterior end of the fourth stomach. As the epithelial cells of the ventriculus only participate in the formation of the pyloric valve (Fig.106;PVlv), it may be called the ventricular valve. The malpighian tubules open at the anterior end of anterior intestine. The epithelial layer (Fig.106; Epth) of the anterior intestine consists of cubical cells. The small nuclei invariably lie towards the inner end of the cells. The epithelium rests over a thin basement membrane (Fig.106; Bmb_1) and is lined internally by a thin intima (Fig.106; In). The circular muscles (Fig.106; cml) lie below the basement membrane and the longitudinal layer (Fig.106; lml) forms the

outer most lining of the anterior intestine. Malouf (1933) termed the anterior intestine as ileum and described the muscularis in the reverse order i.e. circular layer lying external to the longitudinal muscle layer.

(ii) The posterior intestine (Rectum) (Figs.102 and 106;Rct).- It is an elongated sac-like structure with anterior broad region tapering out into a narrow tube to open finally at the anal vestibule. It is demarcated from the anterior intestine by a marked constriction (Fig.106; k). The latter marks the position of internal rectal valve (Fig.106; RVlv) which guards the opening of the anterior intestime into the rectum.

The epithelial layer develops columnar cells to form the rectal valve. The epithelial layer of the rectum is quite distinct and rests upon the basement membrane (Fig.106; Bmb_2). The cell walls have altogether disappeared. The nuclei therefore do not follow any general plan and lie scattered in the cytoplasm. A thin intima forms the lining of the epithelial layer. The muscularis includes the inner circular and outer longitudinal muscle layers. The rectal pads are totally absent. Malouf (1933) considers that the epithelium of the rectum is wanting.

The salivary glands (Fig.107).— These consist of a pair of elongated tubular principal and a highly coiled tubular accessory glands. The principal salivary glands (Fig.107; pSgl) includes two anterior and four posterior elongated lobes. The inner anterior and posterior lobes are closely applied to the outer surface of the oesophagus and crop respectively. The

accessory glands (Fig.107; aSgl), on the other hand, run as convoluted narrow tubes throughout the whole length on the outer surface of the principal glands. The accessory glands open into the latter near the junction of the anterior and posterior lobes. The salivary ducts arise almost near the opening of the accessory glands from the inner surface of the principal salivary glands. These run in postero-anterior direction all along the lateral sides of the oesophagus. After entering the head capsule these extend almost parallel to each other as separate tubes. Slightly posterior to the salivary syringe these converge and unite to form the common salivary duct which enters laterally into the syringe. Malouf (1933) considers the principal salivary glands to be bilobed. Besides, from his figure (Plate II, fig.6) it appears that the salivary ducts open separately into the copula (salivary syringe).

The histology of the principal and accessory glands is almost similar. The epithelium (Fig.108; Epth) consists of large cubical cells which are laiden with much cytoplasmic granules. The nuclei are also big and lie almost in the centre of the cells. The inner surface of the epithelium is lined with a thick intima (Fig.108; In) while a thin non-nucleated layer (Fig.108; prs) envelops the epithelial layer.

The histology of the salivary duct is similar to that of the glands. The epithelium (Fig.109; Epth) is composed of small cubical cells which have small nuclei. The intima (Fig.109; In) is developed internally while a non-nucleated layer (Fig.109;prs)

form the outer covering. The muscular layers are absent. Malouf (1933) considers that the epithelium consists of columnar cells and is enveloped by a nucleated peritoneal layer.

2. The Excretory System

The function of excretion is mainly performed by four long, slender and convoluted narrow malpighian tubules (Fig.102; mt_{1-4}). The distal free end of each tubule is closed while the proximal end of one tube joins that of the other of its side to form a short common canal. The two canals thus formed open on either side of the anterior intestine.

The histology of the malpighian tubules conforms to those of other insects. The epithelium (Fig.110; Epth) consists of large cubical cells with granular cytoplasm. The nuclei (Fig.110; nu) are fairly big and mostly occupy the distal end of the cells. The epithelial layer rests upon a thin basement membrane (Fig.110; BMb) which forms the outer most layer. The inner end of the epithelial cells develop cilia-like processes(Fig.110; cp), the distal ends of which hang freely in the lumen. These cilia appear as a broad striated border and to a large extent reduce the lumen. There is no internal intima lining the epithelial cells. The muscular layers are also absent. Malouf (1933) is silent regarding the histology of malpighian tubules.

3. The Vascular System

The circulatory organs of Leptocorisa varicornis include the dorsal blood vessel and the dorsal diaphragm. The latter demarcates the small pericardial cavity (dorsal sinus) from the large perivisceral-cum-ventral sinus, the ventral diaphragm being absent.

(i) The dorsal vessel (Fig.111).— It is situated mesally above the dorsal diaphragm and runs from the eighth abdominal segment to the posterior end of the protocerebral lobes of the brain. It is differentiated into an anterior aorta and a posterior part, the heart.

The heart (Fig.111; Ht).— It is a narrow tubular vessel lying below the abdominal terga. It is the chief pulsating organ and extends from the eighth to the second abdominal segments. The heart is surrounded dorso-laterally by a mass of pericardial and fat cells. All along the lateral margins of the heart are also situated a double row of oenocytes (Fig.111; Oe). The heart dilates at regular intervals to form three swellings or chambers, each lying from fifth to seventh abdominal segments. The chambers are fairly distinct though in few individual cases these are not sharply marked off. Besides, the size of the chambers also varies in different individuals. The three chambers of the heart diminish in size regularly from posterior to anterior direction and therefore the posterior most chamber is the largest while the anterior one, the smallest. Each chamber is broader posteriorly and narrows

down towards the anterior end to pass into the next chamber. The first (posterior) chamber ends abruptly towards its posterior end and is completely closed while the last (anterior) chamber extends anteriorly to pass into the aorta. A pair of vertical slit-like apertures commonly known as ostia (Fig.lll; os), are situated almost in the middle of each chamber. There are three pairs of ostia, each pair corresponding to one chamber of the heart. Malouf (1933) described in Nezara a single large swelling of the dorsal vessel with three pairs of ostia.

The aorta (Fig.lll; Ao).— It is a narrow and slender tube extending from the second abdominal segment upto the posterior end of the brain. It sink down in the posterior half of the metathorax to run antero-ventrally beneath the large meso-postphragma. After emerging out of the latter it runs in antero-dorsal direction within the mesothorax to pass below the mesal emargination of the prephragma. It finally runs straight above the oesophagus upto the posterior part of the protocerebrum where it is slightly broader and ends in two short lateral branches or capillaries. The lateral walls of the aorta are lined with a single row of indistinct oenocytes.

(ii) The dorsal diaphragm (Fig.lll; ddph).— It is developed only in the abdomen where it extends from the posterior margin of the second to eighth tergum. It is represented by two thin membranes which enclose its muscles. The dorsal diaphragm demarcates a small dorsal pericardial cavity from the rest of the peri-visceral-cum-ventral cavity. There are three pairs of triangular

diaphragm (alary) muscles (Fig.111; Nos.89-91) each of which corresponds to the same abdominal segment which possesses the chamber of the heart. The alary muscles originate from the middle of the lateral side of the tergum and diverge to form the broad base of the triangle and get inserted on the ventral wall of the heart.

(iii) The dorsal sinus.— The dorsal diaphragm cuts off dorsally the pericardial cavity or the 'dorsal sinus'. The heart and the proximal part of the aorta is enclosed within the dorsal sinus. Besides, the tracheae, fat cells and pericardial cells also lie within it.

The ventral diaphragm is absent and therefore the perivisceral cavity and the ventral sinus are confluent. The perivisceral-cum-ventral sinus encloses the alimentary canal, malpighian tubules, ventral nerve cord, the tracheae and the reproductive organs.

4. The Respiratory System

The respiratory system consists of the spiracles (Figs.112, 113 and 114) and the tracheal tubes (Fig.115). The number of the thoracic spiracles is constant, being two pairs in each sex, while the distribution of the abdominal spiracles varies in both the sexes. There are six pairs of the spiracles in male

and seven pairs in female. Thus the total number of spiracles present in male and female Leptocorisa is eight and nine respectively. As regards the position of the spiracles it has been mentioned in the preceding pages that the thoracic spiracles have a 'pleural' position and the abdominal spiracles are mostly confined to the parasternites. The last or the seventh pair of abdominal spiracles in female lie on the paratergite of the eighth segment while those of the male are absent due to the fact that the eighth segment is highly reduced dorsally and covers latero-ventrally the retracted ninth segment. The component structures of the thoracic spiracles are almost identical and there is hardly any difference in their working also. The abdominal spiracles differ from the thoracic spiracles in having a prominent process, the manubrium and in the absence of the operecula. The thoracic spiracles open while the abdominal spiracles close by their own elasticity. The tracheation of the body includes the short spiracular tubes which extend from the atrium of each spiracle and give rise to the dorsal, visceral and ventral tracheae. The dorsal tracheae unite in a series to form the dorsal longitudinal trunk. The ventral tracheae of the corresponding sides extend transversely and join to form the ventral commissure. The visceral and ventral longitudinal trunks are absent.

The mesothoracic spiracles (Fig.112).— These are the anterior most spiracles having almost a vertical position and lying within the intersegmental membrane between the prothorax and mesothorax. The mesothoracic spiracles are overlapped by the flap-like post

coxal bridge of the prothorax. These are provided with an external type of closing apparatus. Each spiracle is furnished with a pair of elongated valve-like lips or s opercula (Fig.112; L_{1-2}) which are separated from one another by a vertical slit (Fig.112; s_1). The anterior and posterior opercula are almost of equal size. The outer surface of both the lips is sharply convex while the inner face is concave. The ventral margins of both the opercula become united by a common sclerotized process (Fig.112; pr_1). The anterior and posterior lips are movable and are regulated by a single fan-shaped occlusor muscle (Fig.112; No.92). The latter arises from the ridge 'r_1' of the peritreme (Fig.112; per_1) and gets inserted on the sclerotic lobe. When the muscle contracts, the two opercula come nearer thereby closing the spiracular opening. The spiracles open by their own elasticity. Malouf (1933) considers that the hairs guard the entrance of the mesothoracic spiracles of Nezara. The present writer could not find any such hairy outgrowth either on the peritreme or the opercula of the insect under review.

The metathoracic spiracles (Fig.113).— These are also vertical in position and unlike those of the mesothoracic spiracles, have migrated more anteriorly to lie almost in the middle of the dorso-ventral carina of the mesothoracic epimeron. The spiracles have the lip-type of closing mechanism. These are provided with opercula (Fig.113; Op_{1-2}) which are set apart by a vertical slit (Fig.113: s_2). The anterior and posterior opercula are elongated and equal in size. Their outer surface is convex while the inner

one is concave. The two lips are joined together by the ventral sclerotic lobe (Fig.113; pr_2). The occlusor muscle (Fig.113; No.93) which originates from the ridge ' r_2' of the peritreme (Fig.113; per_2) is inserted on the outer surface of the sclerotized process. The opercular aperture is closed by the contraction of the occlusor muscle and reopens by its own elasticity. Malouf (1933) regards that the hairs situated on the epimeral flap of Nezara help to guard the entrance of the spiracles. In Leptocorisa varicornis such structures forwarding off the foreign matter are absent on the epimeral flap as well as on the opercula.

The abdominal spiracles (Fig.114).— The abdominal spiracles are provided with an internal closing apparatus. Each spiracle opens to the exterior through a circular aperture (Fig.114; ap) the margin of which is strengthened by a strong ridge (Fig.114; rd). The spiracular opening becomes invaginated to form internally a short tubular atrium. The spiracles have neither the hairy growth nor the operculum. The atrium leads into a short spiracular trachea (Fig.115; Spt). The whole of the anterior wall (aw) of the atrium is supported by a sclerotic bar (sbr) which is produced ventrally into an elongated process, the manubrium (Fig.114; mnb). . The latter is broad at the base, directs posteriorly and tapers out distally into a blunt apex. At the same time the anterior wall is movable and therefore plays an important role in the operation of the spiracle. The posterior wall (pw) does not posses any sclerotic bar and is thoroughly rigid. The dilator muscle (Fig.114; No.94) originates from a small oblique ridge ' r_3' which is situated

anterior to the spiracle on the parasternite. It runs in dorso-posterior direction to end on the distal end of the manubrium. Its contraction opens the spiracular aperture and the spiracle closes by its own elasticity.

The tracheation of the body (Fig.115).— The tracheal system shows a regular arrangement in the body and essentially includes the small spiracular tracheae (Spt) which originate from the respective spiracles and run inward to give off three main branches viz., the dorsal (Dt), visceral (Vst) and ventral (Vt) tracheae. The dorsal tracheae (Dt) become connected from the first thoracic to the last abdominal spiracles to form the dorsal longitudinal trunks (dlTr) which run on either side of the body. No other longitudinal trunks are met with. The ventral tracheae of the corresponding sides unite below the ventral nerve cord to form the ventral commissures (1-3vTCom and $vTCom_{1-7}$).

(i) Tracheation of the head (Fig.115).— The dorsal most tracheae which extend anteriorly from each mesothoracic spiracular tracheae bifurcate at their base before entering into the head. Of these two main longitudinal tracheae, the dorsal branches (Dt) extend as straight tubes and give off branches to the eyes (Opt), mandibles (Mdt) and antennae (Antt). The ventral tracheae, on the other hand, sink down and supply the muscle of maxillary stylets, salivary syringe and sucking pump.

(ii) Tracheation of the thorax (Fig.115).— A short dorso-ventrally elongated tube extends from the first or mesothoracic

spiracle. Malouf (1932) considers them to be the air sacs in Nezara, but in Leptocorisa these show definite spiral ridges (taenidia). The present writer, therefore, is not prepared to accept his view and further suggests to call them 'spiracular tracheae'. There are five main tracheae which extend from the anterior spiracular trachea. Of these two are dorsal, a mesal and two ventral in origin. The first or dorsal most trachea proceeds anteriorly and soon divides into two longitudinal tracheae (Dt and Vt); the second dorsal trachea (adMst) extends posteriorly into the anterior half of the mesothorax; the median trachea leads into the prothorax and divides at its base into a dorsal (dPrt) and a ventral (vPrt) tracheae spreading over the respective dorsal and ventral regions of the prothorax. The ventral branches of the corresponding sides unite to form the transverse ventral commissure (lvTCom). The first ventral trachea (avMst) runs posteriorly to spread over the antero-ventral muscles of the mesothorax. The last trachea (Prtl) which extends from the ventral side of the spiracular trachea enters into the lumen of the fore leg. The dorsal longitudinal trunk (dlTr) which runs anteriorly from the metathoracic region, ends at the point of origin of the second dorsal trachea of the mesothoracic spiracular trachea.

The second or metathoracic spiracles give origin to the spiracular tracheae which with the increase in size of the spiracles have also become much distended dorso-ventrally. From the metathoracic spiracular trachea (2 Spt) extend seven principal tracheae of which two are dorsal one median (visceral) and four ventral in origin. The first dorsal trachea (pdMst) runs anteriorly

and branches over the posterior tergal muscles of the mesothorax. The second dorsal trachea (adMtt) directs posteriorly and spreads over its antero-dorsal muscles. The median or visceral trachea (Thvst) divides at a short distance from the base into the dorsal and ventral branches which ramify the respective parts of the gut lying within the pro- and mesothorax. The first ventral trachea (Msvt) proceeds from the ventral half of the spiracular trachea and gives off a dorsal and a ventral sternal trachea. The main stem extends below the ventral nerve cord and joins with that of the other side to form the mesothoracic ventral transverse commissure (2vTCom). The next ventral trachea (vMtt) runs posteriorly, gives off similar dorsal and sternal branches and finally forms the metathoracic ventral transverse commissure (3vTCom). The third and fourth ventral tracheae extend one after the other from the spiracular trachea. The former (Mstl) directs antero-ventrally while the latter (Mttl) proceeds postero-ventrally to enter into the middle and hind legs respectively.

(iii) Tracheation of the abdomen (Fig.115).— A short spiracular trachea extends from each abdominal spiracle (first to sixth in male and first to seventh in female). From each spiracular trachea (Spt_{1-7}) proceeds inward three main branches. The dorsal trachea (Dt_{1-7}) divides above into two branches which unite with similar tracheae of the successive segments to form the dorsal longitudinal trunk (dlTr). The latter which extends on either sides of the body also gives off branches to the dorsal diaphragm and the dorsal vessel. The visceral branch (Vst) runs mesally and bifurcates into the dorsal (dVst) and ventral (vVst)

tracheae which supply the respective regions of the viscera. The visceral branch of the first abdominal spiracle also gives off anteriorly a trachea (pThvst) which ramifies the posterior thoracic viscera. Lastly the third or ventral trachea (Vt_{1-7}), after giving off the dorsal (dVt) and ventral sternal (VSt) branches, runs inward to unite in mid-ventral line with the corresponding trachea of the other side. The ventral transverse commissures ($vTCom_{1-7}$) thus formed pass under the ventral nerve cord. The ventral tracheae of the fifth, sixth and seventh spiracles provide origin to another set of ventral branches which spread over under surface of the reproductive organs.

The abdominal tracheation varies slightly in the posterior abdominal segments of both the sexes due to unequal distribution of the spiracles. The description of the tracheation of abdomen given so far refers to that of the female Leptocorisa. In male the last or sixth spiracle gives off the usual spiracular trachea from which spring up the dorsal, visceral and ventral tracheae. The dorsal longitudinal trunk extends posteriorly where it sends off terminal branches to the dorsal surface. The visceral and ventral tracheae take up a longer course and become much branched so as to supply the contents of the seventh, eighth and ninth abdominal segments. The last ventral transverse commissure is formed in the seventh segment.

5. The Nervous System

The nervous system includes the central nervous system consisting of the brain and ventral nerve cord with their ganglia and nerve connectives and the sympathetic or stomodaeal nervous system.

The brain (Figs.116 and 117).— It lies dorsally in the posterior (occipital) region of the head capsule and is divided into three distinct parts namely the protocerebrum, deutocerebrum and tritocerebrum.

(i) The protocerebrum (Figs.116 and 117; 1Br).— It is the largest part of the brain and occupies a major area of its dorsal surface. Its two lobes become fused mesally forming externally a clear line of fusion which appears as a longitudinal furrow (Fig.116; mf). A small ocellar nerve (Fig.116; ON) arises from the mid-dorsal region of each protocerebral lobe. From each lobe of the protocerebrum extends antero-laterally a large optic lobe or optic ganglion (Figs.116 and 117; OpL). The latter is elongated with broad proximal and narrow distal ends. The proximal end of the optic lobe gets fused with the protocerebral lobe. The line of fusion is represented externally by an almost regular circular furrow (Figs.116 and 117; cf). The distal end of the optic lobe is in direct communication with the compound eye while its mesal area is quite free.

(ii) The deutocerebrum (Figs.116 and 117; 2Br).— This middle part of the brain is much smaller and lies ventral to the

protocerebrum. Its narrow mesal region appears as a thin strap. Antero-laterally it develops a pair of 'antennal lobes' or antennal ganglia (Fig.117; AntGng). The latter are separated from the protocerebrum by their dorsal surface while the ventral surface demarcates them from the tritocerebrum. Each antennal lobe gives out anteriorly a long and slender antennal nerve (Figs.116 and 117; AntN) which enters into the antenna of the corresponding sides.

(iii) The tritocerebrum (Figs.116 and 117; 3Br).— The hind brain is a pair of small oval lobes each lying ventral to the antennal lobe of the deutocerebrum. The two lobes of the tritocerebrum are connected with each other by a short tritocerebral commissure (Fig.117; 3BrCom) which passes below the anterior pharynx. Each tritocerebral lobe gives out anteriorly a short and stout fronto-labral nerve (Figs.116 and 117; FrLrCon). A long and slender labral nerve (Figs.116 and 117; LBN) originates a little anterior to its base and enters the labrum. The fronto-labral nerve extends anteriorly and ultimately ends on the frontal ganglion (Figs.116 and 117 FrGng). From the posterior part of each tritocerebral lobe extends a very short and strong circum-oesophageal connective (Fig.117; CoeCon) which passes below the pharynx to join with the sub-oesophageal ganglion (Figs.116, 117 and 118; SoeGng).

The ventral nerve cord (Fig.118).— It consists of the sub-oesophageal, prothoracic and pterothoracic-cum-abdominal ganglia with their connectives. The sub-oesophageal ganglion (Figs.116,

117 and 118; SoeGng) is single while the other two are paired. The paired ganglia get fused along their inner margins to form a single mass. Each ganglion of the ventral nerve cord is connected with the one following it by a pair of interganglionic connectives (Fig.118; IGnCon).

(i) The sub-oesophageal ganglion (Figs.116, 117 and 118; SoeGng).— It is an unpaired more or less polygonal ganglion with broad anterior and narrow posterior regions. It lies below the pharynx and gives out posteriorly a pair of short and stout interganglionic connectives which are almost fused along their mesal surface. These connectives pass through the foramen magnum and enter into the prothorax to end on the anterior margin of the prothoracic ganglion. Besides, the three paired nerves viz., the mandibular, maxillary and labial nerves (Fig.118; MdN, MxN, LbN), originate one after the other from its lateral sides and innervate the muscles of the respective parts.

(ii) The prothoracic ganglia (Fig.118; PrthGng).— These are paired but the two ganglia are fused along the mid-longitudinal line in a such a manner as to give an appearance of a single mass. It is slightly smaller than the suboesophageal ganglion and is situated on the basisternum. Its anterior broad end receives from the sub-oesophageal ganglion a pair of interganglionic connectives while the narrow posterior end gives out a pair of similar connectives (Fig.118; IGnCon) which end on the anterior end of the pterothoracic-cum-abdominal ganglia. The prothoracic ganglia give out three pairs of short nerves. The first (anterior)

(Fig.118; a) innervatives the anterior muscles of the prothorax; the second (middle) (Fig.118; b) innervatives the extrensic muscles of the fore-legs and the third (Fig.118; c) enters into the lumen of the foreleg to supply its intrensic muscles.

(iii) The pterothoracic-cum-abdominal ganglia (Fig.118; Ptth Ab- Gng).— These are elongated with broad mesal and narrow anterior and posterior regions. Like that of the former these are also paired and have undergone a similar fusion. The fused ganglia are situated in basisternum of the mesothorax. A horizental section as well as the 'Borax carmine' stain clearly indicate the position of three well-defined ganglionic centres. The first, second and third centres represent the mesothoracic, metathoracic and abdominal ganglior respectively (Fig.118; M_1, M_2 and Ab). Three pairs of nerves originate from the antero-lateral margin of the mesothoracic mass. The first or the inner most nerve (Fig.118; d) supplies to the tergal longitudinal muscles; the second (Fig.118; e) innervates terga-sternal muscles and the muscles of the mesothoracic wings, while the third nerve (Fig.118; f) bifurcates into two branches. The anterior branch (Fig.118; f_1) innervates the extrensic muscles while the posterior one (Fig.118; f_2) supplies the intrensic muscles of the mesothoracic legs. Three paired nerves also arise laterally from the metathoracic ganglionic centres. The anterior (Fig.118; g) and middle (Fig.118; h) nerves innervate the anterior and dorsal muscles of the metathorax while the posterior one (Fig.118; i) divides into two branches. The outer branch (Fig.118; i_1) innervates the extrensic muscles and the inner one (Fig.118; i_2)

enters into the leg to supply the intrensic muscles of the hind legs.

The abdominal ganglionic mass gives out four pairs of separate divergent nerves (Fig.118; I-IV AbN) which run posteriorly beneath the odoriferous sac and innervate the first four abdominal segments. Malouf (1933) considers that the last three nerves crosss one another at a point 'O' in the metathorax. The present writer could not find any such crossing in the insect under review. The paired median nerves (Fig.118; mN) extend posteriorly from each of the two ganglionic centres and become fused along their mesal surface. The median nerve gives out five pairs of nerves. The nerves (Fig.118; V-VI AbN) innervating the fifth and sixth segments originate from the anterior margin of the third and posterior margin of the fourth abdominal segments respectively. The remaining three pairs of nerves arise from the posterior margin of the sixth segment. The inner (Fig.118; VII AbN) and outer Fig.118; IX AbN) nerves supply to the respective seventh and ninth segments while the middle one (Fig.118; VIII AbN) innervates the eighth segment. A small branch from the outer nerve of the ninth segment innervates the post-genital segment.

The stomodaeal nervous system (Fig.119).— It consists of the frontal, pharyngeal and stomachic ganglia with their associated nerves.

The frontal ganglion (Figs.116, 117 and 119; FrGng) is situated on the dorsal surface of the anterior pharynx between the accessory dilator muscles of the sucking pump and the dilators

of the anterior pharynx. It is connected with the tritocerebral lobes by the frontolabral nerves. From its posterior region arises a single recurrent nerve (Figs. 116, 117 and 119; RN) which runs dorsal to the posterior pharynx below the dorsal aorta. The recurrent nerve ends on the anterior part of the pharyngeal ganglia (occipital ganglion). The paired pharyngeal ganglia are situated on the dorsal surface of the posterior pharynx. The two oval ganglia are fused along their inner margins and receive anteriorly the recurrent nerve (Fig.119; OcGng). From the antero-dorsal surface of each of the two pharyngeal ganglia arises a short nerve (Fig.119; OcN) which connects it with the posterior part of the brain (Fig.119; pmBr). A small globular structure, the corpora allatum (Fig.119; Ca) is attached to the latero-ventral region of the pharyngeal ganglia.

A pair of nerves arise from the posterior end of the pharyngeal ganglia. These run posteriorly almost parallel to one another over the oesophagus and end on the anterior region of the stomachic ganglion (Fig.119; SGng) which is situated on the anterior part of the crop.

Malouf (1933) considers that in Nezara "the frontal ganglion represents all there is of the stomatogastric nervous system". In the opinion of the present writer the saddle-shaped globular body and its lateral swellings which Malouf (1933) considers to be "excretory body" represent the corpora allatum and the paired pharyngeal ganglia of L.varicornis respectively. The present writer confirms the observations of Nesbitt (1941) who has

clearly shown the well-defined stomodaeal nervous system in heteropterous insects.

6. The Reproductive System

The sexes are separate and the males are slightly smaller in size than the females. The latter can be distinguished from males by the presence of pointed posterior tip of the abdomen, the well developed ovipositor and by the absence of claspers.

(A). The Female Reproductive Organs (Figs.120-122).— These are composed of a pair of ovaries and a pair of lateral oviducts which converge to form the median oviductus communis. The other accessory structures are the spermatheca and a pair of accessory glands which open into the genital chamber.

(i) The ovaries (Fig.120; Ov).— Each ovary extends from the posterior half of metathorax to the anterior half of the fifth abdominal segment and is placed dorso-lateral to the crop. It consists of seven ovarioles which open into the lateral oviduct (Fig.120; lod) of the corresponding side. Each ovary is susnended by the suspensory ligament (Figs.120 and 121; TF).

(a) The ovariole (Figs.120 and 121; Ovl).— Each ovariole includes the terminal filament, the egg tube and a very short supporting stalk or peduncle. The ovariole is enveloped by a double membrane, an outer peritoneal membrane and an inner tunica (Fig.121; prs and Int).

(b) The terminal filament (Figs.120 and 121; TF).— The long and slender thread like filament arises from the anterior part of each ovariole and gets attached with its fellow members of the same side to form the so-called suspensory ligament. The latter extends as far anteriorly as the indirect principal levator of forewing and acts as suspensorium for the ovary. The terminal filament is a solid rod of cells and is covered externally by the peritoneal layer. The inner tunica is absent in this region.

(c) The egg tube (Figs.120 and 121).— It is composed of two regions namely the zone of germarcum and the zone of growth or vitellarium. The zone of germarium (Fig.121; Grm) is filled with germ cells which give rise to the nurse cells, follicle cells and oocytes. The nurse cell (Fig.121; Nrcl) retain their position in the upper region of the germarium. The oocytes shift downwards from the germarium one after the other and develop in the vitellarium (Fig.121; Vtl). The nutritive (yolk-forming) substance is conveyed from the nurse cells to the oocytes by long plasmatic strands (Fig.121; ns). The retention of the nurse cells in the germarium and the mode of nutrition to the oocytes present an acrotrophic condition to the egg tube.

The successive production and development of the oocytes (Fig.121; Ooc) bring about an increase in the length and width of the vitellarium which thereby assumes a bead-like appearance. The follicle cells (Fig.121; Fcl) are arranged in the manner of epithelial cells at the periphery of the proximal (upper) end of the vitellarium. But these form well defined follicular walls between

the fully developed eggs, as a result of which the distal (lower) end of the vitellarium presents a number of egg chambers or follicles. The oocyte first produced is the largest (Fig.121) and lies within the distal most egg chamber of the vitellarium.

(d) The lateral oviducts (Figs.120 and 122).— The ovarioles of the corresponding sides lead into a pair of long tubes, the lateral oviducts (Fig.120; 10d) which follow a convergent course to open into the common oviduct. Its epithelium (Fig.122; Epth) is much convoluted and consists of cubical cells with small nuclei. The longitudinal muscle layer (Fig.122; lml) surrounds it externally while the circular muscle layer (Fig.122, cml) lies outside it. The non-nucleated peritoneal layer (Fig.122; prs) forms the outer most coverying.

(e) The oviductus communis (Fig.120; Odc).— It is followed by the lateral oviducts and extends posteriorly upto the eighth sternum. It communicates with the genital chamber through its posterior opening, the gonopore (Fig.120; Gpr). Its histology is almost similar to that of lateral oviduct. The epithelial layer consists of comparatively larger cubical cells and the nuclei are arranged almost in the middle of the cells. The lumen can be greatly distended due to the presence of longitudinal folds in the epithelium. The latter is surrounded externally by an inner longitudinal and outer circular muscle layers. The whole duct is enveloped by a non-nucleated peritoneal sheath.

(i) The genital chamber (Fig.120; Gc).— It is formed by an inflection of the body wall at the base of the ovipositor behind the eighth sternum. It is an open pouch-like structure and receives the male copulatory organs during mating. The gonopore and openings of the spermatheca and accessory glands are situated at its anterior part which functionally may be called the "vagina".

(ii) The spermatheca (Fig.120; Spt).— It is an unpaired sac-like structure with a short and narrow duct. It lies on the right side of the body and opens into the anterior end of the genital chamber. The spermatheca acts as a reservour for the sperms.

(iii) The accessory glands (Fig.120; Acgl).— The paired highly convoluted long and slender accessory glands open into the genital chamber between the bases of the ovipositor and the second valvifer on the ventral surface of the ninth segment. Their secretion is mainly responsible for gluing the eggs to the substratum and providing a uniform hard protective covering to the eggs.

(B). The Male Reproductive Organs (Figs.123-128).— These include a pair of testes, the vas deferentia which become enlarge to form vesicula seminalie, a median ductus ejaculatorius and a series of glands originating from the lateral sides of the latter.

(a) The testes (Fig.123; Tes).— These are yellowish and oval and are placed in the fifth abdominal segment dorso-lateral to the posterior part of the crop. The dorsal surface of the

testis is convex while the ventral concave surface is closely applied to the convex wall of the crop. Each testis is composed of seven short and slendes tubes known as sperm tubes (testicular follicles) (Figs.123 and 124; Spt). Each follicle is broad mesally and tapers out at both ends. It is closed at the proximal (anterior) end while at the distal (posterior) end it forms a short stalk, the vas efferens (Fig.125; ve) which opens into the vas deferens (Fig.123; Vd).

Each testes is surrounded externally by a thin peritoneal layer (Figs.123 and 124; prs). The sperm tube of the testis is enveloped by the epithelial sheath which is divided into an outer and an inner layer. The outer layer (Fig.125; oEpth) is non-nucleated and acts as a reservoir for the pigment granules. The inner layer (Fig.125; iEpth) is placed next to the outer epithelial layer and surrounds the lumen. Its cell walls are indistinct and the small nuclei are irregularly arranged. A thin basement membrane (Fig.125; Bmb) lies between the two epithelial layers. All the sperm tubes of each testis are surrounded externally by a peritoneal sheath (Figs.123 and 124; prs).

Each sperm tube encloses the germ cells which are in various stages of development. The proximal closed end which is filled with primary spermatogonia (Fig.125; Stg) can be recognized as germarium. In this region the spermatogonia occur in groups which are enveloped by a cyst. Before entering the zone of growth (Fig.125; Zg) the cyst dissolves and the spermatogonia thus

liberated accumulate in two to three large groups. In the zone of growth each spermatogonium gets encysted and enlarged. Next these enter into the maturation zone and undergo reduction division (Fig.125; Rd) to form the spermatocyts. The latter in the zone of transformation give rise to spermatids (Fig.125;Spd) which in turn develop thread like spermatozoa (Fig.125; Spz).

(b) The vas deferens and vesicula seminaalis (Fig.123;Vd and Vsm).— The vas deferens extends as a long and slender tube from the posterior side of each testis. It abruptly swells up in the distal half to form the vesicula seminalis (Fig.123; Vsm). The latter follows a convergent course below the mid-gut to become connected with the ductus ejaculatorius. The histology of vas deferns and vesicula seminalis is almost similar. The epithelium (Fig.126; Epth) consists of small cubical cells with nuclei arranged regularly in the middle. The epithelial layer rests upon a thin basement membrane (Fig.126; Bmb) and the thin layer of the circular muscles (Fig.126; cml) lies external to it. The circular muscle layer is enveloped by the peritoneal sheath (Fig.126; prs).

(c) The ductus ejaculatorius (Fig.123; Dej).— It is an unpaired elongated tube running mesally below the hind gut. Its proximal narrow end is almost regular while the distal end narrows down considerably to enter into the aedeagus.

The histology of the proximal region differs from that of the distal parts. The epithelial layer (Fig.127; Epth) of the

proximal part is composed of columnar cells with small nuclei arranged regularly in the basal part of the cells. The epithelium is limited externally by a basement membrane (Fig.127; Bmb) while a thin intima (Fig.127; In) surrounds it internally. The circular muscle layer (Fig.127; cml) forms the outer most covering of the duct.

The epithelium (Fig.128; Epth) of the distal region consists of cubical cells and the nuclei lie almost in the middle of the cells. The epithelial layer rests upon the basement membrane (Fig.128; Bmb) external to which is a thick layer of circular muscles (Fig.128; cml). The circular cuticular intima (Fig.128; cIn) gets support from two curved hook-like processes (Fig.128; ch) and is kept suspended within the lumen. Each of the two arms extend into the corresponding lateral projections of the tube and are supported by its dorsal and ventral walls.

(d) <u>The accessory glands</u> (Figs.123 and 127; Acgl).— The sac-like accessory glands arise serially from the lateral sides of the proximal half of the ejaculatory duct. The epithelium (Fig.127; epth) consists of columnar cells with elongated nuclei arranged in the basal half of the cells. The circular muscle layer (Fig.127; cml) which forms the external coat is continuous with that of the ductus ejaculatorius.

LIFE HISTORY

OF

LEPTOCORISA VARICORNIS FABR.

V. LIFE HISTORY

Introduction.— Lentocorisa varicornis Fabricius is an important representative of sub-family Alydinae. It was Fabricius(1794) who for the first time distinguished the genus Lentocorisa as Gerris. Latreille (1825) named it as Lentocorisa, a term which is in current use. Subsequently others like Burmeister (1835) and Kolenati (1845) termed it as Myodochus and Rhabdocoris respectively. Burmeister (1839) influenced by his new decision called it Stenocoris. Regarding the species, Fabricius (1803) was the first to classify it as Garris varicornis and was followed by Wolff (1811) who retained this term. Guerin-Meneville (1830) changed the name of the species as Lentocorisa falvida, while Burmeister named it as Myodochus varicornis. In 1852 Dallus gave another synonym, Lentocorisa chinensis.

Lefroy (1908) worked out the life history of Lentocorisa varicornis which can be claimed as a standard work of his time. He was followed by Dutt (1920), Ayyar (1940) and Lal (1946), but all these observations are ~~very precise~~ inconclusive. The present writer has attempted to enter into details which were ~~over-looked~~ left over by Lefroy (1908) and ~~other previous~~ the subsequent workers.

Distribution.— Lentocorisa varicornis is one of the major insect pests of paddy plants in India. It is found in fields along with its sister species viz. L.acuta and L.costalis. Lefroy (1908) has given a long list of the distribution of L.varicornis which covers

almost all the rice growing areas of Uttar Pradesh, Behar, Orissa, Bengal, Madhya Pradesh, Malabar West coast, Kanara and Burma. Fletcher (1910) has also reported it practically from every rice growing region of India. Sheroff (1910) recorded it at Burma while Rao (1922) reported it from Madras. Susainather (1922) observed it in company with L.acuta in Malaya. The present writer has recorded its occurrence at Allahabad, Kanpur, Aligarh, Delhi, Muradabad, Bijnore, Dacca and neighbouring districts. At Aligarh it was found in abundance along with Leptocorisa acuta.

Food plants.— Lefroy (1908) has shown that besides paddy the other plants subjected to its attach are Jowar (Andropogon sorghum Sorgum vulgari Pers.), Bajra (Pennisetum typhoideum Rich.), sugar-cane, sama (Panicum frumentaceum Linnaeus), Marua (Elensine coracana Gaertan) and kango (Setaria italica Beauv.). The present writer could record this pest on the first four plants including paddy.

Damage.— Leptocorisa varicornis is most destructive to paddy plants especially when the ear formation has commenced. The reports of the previous workers invariably show that in Northern India the pest is most injurious during grain forming stage of paddy in September — October, while in southern part it is very active during November — December. The bugs, young and old alike, suck the milky juice of developing seeds and render the seeds underdeveloped and dry. Prior to seed formation it feeds on seedlings by sucking the sap from leaves and tender shoots. Heavy damage

is caused to paddy plants in those cases where there is abundant growth of wild grasses. The present writer could collect just thrice the number of bugs from such fields. It is thus presumed that such wild-grass areas afford best opportunity for mating and increased breeding. The damage done to food plants other than paddy is hardly severe.

Habits of the adult.— After the rains have set in and the growth of wild grasses has commenced, the activities of the pest become apparent. The pest breeds freely due to the presence of abundance of wild-grasses during the period (June- July). In the meantime (July—August) seedling become long enough to become a source of food for the pest. The attack becomes more severe in September and October when the ear formation sets in. When the early sown variety of paddy is harvested the bugs shift their destructive activity on late sown varieties and continue causing damage to plants till November. During winter (December to March) they become inert as a response to unfavourable ecological factors. This inactive phase continues during summer (April to June) and may be attributed to high scarcity of food material i.e. paddy crop.

The males and females are almost of the same size and colour, the only difference lies in the structure of the abdomen. The posterior tip of the males is slightly swollen while those of the females is pointed. In females due to developing eye the abdomen becomes swollen. The slender body and dull reddish green colour of the bug give it an opportunity to avoid the notice of

the enemies. Besides, some pungent and repelling odour emitted from the odoriferous glands seems to help the bugs in defending themselves against the enemies.

Leptocorisa varicornis is a slow flier and when approached takes a short flight. The females are, no doubt, more active than the males and take a longer flight. The bugs are diurnal and their activities accelerate at moderate temperatures. From July to October, when the mornings and evenings are pleasant, they are invariably found on the upper parts of the plants ernecially the ears, while between 10 A.M. to 4 P.M. when the temperature is high, they hide in the lower parts of the plants. From November to middle of December the pest becomes active late in the fore-noon at about 8.30 P.M. When the winter becomes severe the pest is rarely seen. L.varicornis is positively phototrophic and is seen to fall on electric light. Besides, marked increase in activities can be noticed in this medium.

Method of rearing.— The adults collected by means of hand-nets from paddy fields were then kept in medium-sized lantern glass chimneys which were covered on the top with a thin muslin cloth. The chimneys were then placed on glass troughs of 1½" long and 3 1/3" diameter. The glass troughs were filled to three-fourth length with sand soaked in water. Thin shoots, leaves and younge ears of paddy were fixed in sand so that they get regular supply of water and may not turn dry. These shoots, leaves etc. serving as source of food were changed daily in the early part of the

paddy season, while in the later part change was given on alternate days. When the paddy season was over and no leaves etc. were available, the wild grasses were used as source of food in a similar way. The chimneys containing these insects were then placed in a breeding cage measuring 3½' x 2½' with a maximum minimum thermometer placed in it. When the temperature was low (November-February) an electric bulb varying from 25W to 60W (according to the temperature required) was lighted inside the cage. The leaves on which the eggs were laid, were removed and kept in glass troughs covered with small lantern chimeneys.

High mortality was recorded in the first instar and the younge mymphs could not survive longer. It had become a problem to get the moults. The present writer therefore tried different methods, the most successful is the following :

Glass tubes (of the shape of test-tubes) measuring about 12" long and 1¾" diameter were taken and filled for about one-third of their length with sand which was soaked with water to its maximum. Few ripening ears and tender leaves were fixed in the tube so that they may not get dry. The ears and the leaves were changed daily so as to provide a regular supply of fresh food and also to avoid any fungus growth. Only one newly emerged nymph was released in one tube, the top of which was covered with a thin muslin cloth.

Copulation.— It has been observed both in the fields and under captivity. In the field it has been invariably recorded in the

day especially in the morning between 8 A.M. and 9 A.M. In insectary it has also been observed in the night in absence of electric light which impresses upon the present writer that light is not an essential factor for copulation.

One pair of the newly emerged adults were released in large lantern glass chimneys which were placed in a manner described above. It was done so as to allow a greater space for their movements. It has been observed that the males become active sooner than the females. The latter does not offer herself for mating soon after emergence. Copulation usually takes place in about 12-14 days after emergence and lasts for about 3-4 hours. In the field the courtship could not be recorded but under captivity it has been observed. First the male approaches the female from front and moves gently its antennae over that of the female. If she is unwilling, she flies away while the male follows her immediately and repeats the same process again and again. This act is done probably to arouse the sexual urge in the female. When the female offers herself for mating the male extends his abdomen below that of the female and the copulation starts in opposition, that is, their anterior ends point in opposite directions. The usual process of riding of male over female does not happen. For about 2-2½ hours there is absolutely no movement, both remaining inactive, but after that slight movements on the body are observed. It is only the male who initiates such activities. It moves the hind-legs one after the other over its as well as over that of females abdomen. The hemelytra are then

raised and the hind legs are moved in a similar fashion. Afterwards both the fore legs are moved forward, the labium, the antennae and finally the legs themselves are cleaned. The middle legs are then passed over the abdomen in a similar way as described in the case of hind legs. The male repeats the same process again and again at intervals of 15-20 minutes till the copulation is over and both the male and female separate.

Oviposition.— The female starts laying the eggs 3-4 days after coupulation. In captivity the oviposition mostly takes place in the night but the process has also been observed in day time. In the fields the eggs are mostly deposited regularly in a row on the underside of the leaves while in insectary no hard and fast rule is followed and besides leaves the eggs are also deposited on glass chimneys. The eggs are attached firmly to the substratum by means of a sticky substance which on becoming dry hardens thereby forming a protective covering for them. It enables eggs to resist the adverse conditions such as rains, temperature, wind etc. The eggs are invariably laid in clusters which consists of 1-3 rows. They are mostly deposited symmetrically in one row only. In insectary the maximum number of eggs in one row was twelve while the cluster of eggs brought from the fields contained 15-20 eggs in one row. The time taken for depositing one egg varies from 8-10 minutes. The number of eggs laid per day by a single female is 12-19 while the total number of eggs laid by it ranges between 14-30. The female finishes egg-laying in about 2-3 days.

When the female is about to deposit the eggs, it sits in such a manner as the legs are stretched properly far apart from each other and the antennae direct anteriorly. When one egg is laid, the female moves forward and goes on depositing the eggs one after the other till the desired number is reached. The freshly laid egg is creamy white in colour which deepens in about 3-4 hours. In about twelve hours it becomes dark brown and as the time of hatching approaches it becomes darker and darker in colour.

Pre-imaginal stages—

(A) Egg.— Each egg is oval in structure. Its dorsal surface is flat while latero-ventrally it is regularly curved. It is highly convex on the ventral side, the lower most part of which touches the surface on which it is deposited. Its dorsal flat surface measures externally 1.2 mm long and 0.8 mm broad. The dorso-lateral rim of the shell is more sclerotized than the rest and probably assists in the rupture of the shell. Four small black dots, which are placed in a curve, are visible on one end of the dorsal flat size. A white spot, which in dissection reveals to be a circular depression in the membrane surrounding the enclosed embryo, is placed laterally in the middle of the area enclosed by the black dots. This, as will be seen later, is the anterior end of the egg. Lefroy (1908) reported the dorsal surface to be slightly concave but the present writer could observe such concavity only in deformed eggs which did not hatch at all.

(B) Incubation period.— The hatching period of the eggs varies very slightly in pre-winter days when the pest is active. During July - September the eggs generally hatch out in about 4-5 days while in October to December the hatching usually takes place in 5-6 days.

(C) Eclosion from the egg.— The eclosion of the nymph from the egg in insectary mostly takes place in the later part of the night. In more advanced stages of the embryo, it has been observed that the thorax and abdomen lie within the egg on the ventral curved side. The abdomen occupies a major portion while the thorax lies on the antero-ventral region. The head curves upwards so that its occiput lies in the antero-lateral part of the shell. The frons, clypeus and the mandibular plates become dorsal in position. The legs, antennae and labium lie in a curved (more or less coiled and entangled) state on the mid-dorsal region of the shell . Practically in all the cases the upper flat surface breaks off at dorso-lateral rim of the shell, which suggests that the pressure exerted by the young one is confined only to the antero-dorsal region. Moreover an examination of the embryonic covering which is always left behind within the shell confirms it. In the opinion of the present writer the black dots, the chitinized dorso-lateral rim of the shell and the white spots of the head are corelated with each other and have some bearing for the rupture of the shell. The break at the sides of the dorsal flat surface is uniform almost in all the cases, but its posterior

limit is not definite. In few it is about three-fourth while in some two-third and still more in others about half of the upper disc is peeled off. The membrane enclosing the embryo breaks off at the head region and extends upto the thorax. The head followed by thorax protrudes out of the shell. At this stage a greater force can be applied by the emerging nymph to jerk out the body. Later on, the abdomen, legs, antennae and beak wriggles out and the embryonic membranous covering is left behind within the shell.

(D) Nymphal stages.— The newly emerged nymphs pass through five stages to atlain the adult hood. Before undergoing a change the nymph becomes sluggish. It occupies a solitary place and prepares for ecdysis. It sits in such a fashion that the legs are stretched far apart and the antennae direct posteriorly. One by one the legs are moved to and fro, the antennae are also subjected to the same process. This is done probably to loosen the skin which is to be given off. The skin breaks off in the mid-dorsal region of the thorax and extends upto the head, The nymph then pushes forward its body and the head followed by thorax comes out. Its advance in forward direction brings out the antennae and the legs. The posterior tip of the abdomen is the last part to come out. The whole process lasts for about fifteen minutes. Some important remarkable changes are met with in the final moult and the early adult stage. The nymphal periods of different instars vary in different stages. The nymphs attain maturity in about 16-19 days.

(1) First instar.— Just after emergence the nymph is about 1.75 mm. long. The growth being rapid it becomes about 2 mm. in 4-5 hours and by the expiry of first stadium it increases to its maximum of 2.5 mm. The first instar's duration is 3-4 days. The general colour of the body is green with small hairs throughout the body. The division of the body into three regions viz. the head, thorax and abdomen is quite distinct.

(a) The head.— The head is well developed and shows a remarkable resemblance with that of the adult. It is about 0.75 mm. long and 0.47 mm. broad. A dark brown broad patch extends posteriorly from the antennal sclerite to the metathorax. The clypeus is swollen anteriorly and thus the anterior tips of the mandibular plates lie far apart from each other. The deep clefts between clypeus and mandibular plates are distinct. A pair of dark brown four-segmented antennae are placed dorso-laterally in the anterior part of the head. They are lodged in distinct antennal sockets. The antennal sclerite is also clearly visible. The first segment of the antenna is of uniform dark brown colour, the proximal and distal ends of the second segment are dark brown while it is creamy white in the middle. The third segment like the first is dark brown in colour throughout its length. The ring joint is very small. The proximal part of the flagellum is dark brown and is followed by a creamy white patch while the distal half is again of dark brown colour. The antennae are covered with small hairs throughout their length. The two large black compound eyes are situated posterior to the antennae. The ecdysial suture is clearly visible, the frontal arms extending

upto the middle of the compound eyes. The frons is large. The epistomal suture is faintly marked off. The occipital region is broad and the ocelli are absent. The four-jointed long and slender beak arises anteriorly and is kept curved back beneath the body. It extends posteriorly beyond the tip of the abdomen in newly emerged nymph, while in advanced first instar it reaches upto middle of the abdomen. The labium is dark brown in colour having the tip of the apical segment black. The labrum is small and overlaps the first labial segment. The bucculae, maxillary plates, gula and the genae are distinct but the sutures limiting their areas are not visible.

Internally the paired dorso-lateral, paired ventral and the single mid-dorsal process of the hypopharynx are quite distinct. The salivary syringe with piston and handle lies ventral to the mid-dorsal process of the hypopharynx. The maxillary and mandibular stylets with their respective levers are well developed and occupy a position similar to that of the adult.

(b) The thorax.— It is fairly long and is divided into three well marked regions viz. the pro-,meso-,and metathorax. The transverse grooves limit the areas of each, the posterior most groove separating the metathorax from the abdomen. The posterior extensions of the protergum of adult is lacking. The prothoracic tergum is broader than that of meso- and metathorax. The thoracic spiracles are uncovered. The phragmatal lobes are yet undeveloped. One clear line appears in the

mid-dorsal region of the thorax and marks off the line of ecdysial cleavage. It is in continuation with the coronal suture and extends posteriorly as far as the middle of the metathorax. The pleural folds (episternal and epimeral folds of adult) are undeveloped. The trochantin is present and the coxa has both the pleural and trochantinal articulations. The basicostal suture is distinct and demarcates the coxa into two parts, the anterior being the basicoxite. Each division of the thorax bears a pair of moveable appendages, the legs. The fore-legs are the smallest while the metathoracic legs are largest. The trochanter, femur and tibia have the resemblance of the adult. The tarsi are two segmented and the pretarsus bears a pair of claws. The legs are dark brown in colour with numerous dark hairs of varying sizes.

(c) The abdomen.— It is broad anteriorly but in the newly emerged nymph it abruptly tapers out posteriorly. In the first instar of advance stage, the posterior tapering of the abdomen is gradual. The abdomen is divided into eleven segments, the eleventh being the smallest in the form of a ring and carries the anal opening. The grooves separating one segment from the other are feebly marked off. There are eleven tergal plates, there being no paratergites. Mesally on the fifth and sixth tergum are situated the openings of the odoriferous glands. The first abdominal sternum has become fused with the metasternum. Thus there are only ten sternites, the first actually being the second. The parasternites are faintly marked off from the sternum. There are seven pairs of abdominal spiracles which occur laterally on

second to eighth sternite. There are no abdominal appendages. The genital armature has not yet made its appearance.

(ii) Second instar.— The nymph after casting off its skin becomes active. It is about 2.8 mm. long and grows upto a maximum size of 4.5 mm. in the second instar. There are no marked change in the colour of the body, antennae, beak and legs. The head is about 1.08 mm. long and 0.7 mm. broad. The rostrum now reaches only upto third abdominal sternum. The postcoxal bridge of the prothorax is rudimentary. The anterior extension of the protergum which surrounds the postoccipital region of the head is distinct. The lateral extension between the tergal and sternal region become developed. These flaps in the prothoracic region are longer than those of the meso- and metathorax. The sternal furca become quite distinct while the pleural apophyses are absent. The abdomen becomes larger in size. Besides the above there are no other marked changes in the second instar. The nymph remains in this stage for an average period of 2-3 days and then undergoes another moult.

(iii) Third instar.— In this stage the nymph grows upto a maximum length of 6.8 mm. There is no change in the colour of the body. The lateral dark brown strap extending posteriorly from the antenna to the metathorax becomes dull in colour. The head is now about 1.78 mm. long and 1.1 mm. broad. The beak reaches upto the hind coxae. The protergum extends posteriorly over the anterior part of mesotergum. The basisternum of prothorax is distinct. The prephragma is still undeveloped and the postphragma makes

its first appearance. The wing buds of both pairs also appear. The first pair belongs to mesothorax and is dorsal in position while the second pair originates from the metathorax and lies beneath the first pair. The wing buds of the first pair extend upto the middle of the metathorax while those of the second pair reach upto the posterior margin of the metathorax. The two thoracic spiracles are still uncovered and lie laterally in the intersegmental space between the pro- and mesothorax and the meso- and metathorax. The pleural apophysis of the pro- and metathorax become distinct while that of the mesothorax is rudimentary. The colour of the legs upto tibia become dull and the two jointed tarsus retains its original dark brown colour. There is no remarkable change in the structure of the abdomen except that it has become increased in size and in females a streak appears ventrally in the eighth sternum. The third stage lasts for 2-3 days.

(iv) Fourth instar.— The maximum length attained by the nymph in this instar is about 10.5 mm. The body and its appendages retain their original colour. The head increases in size and is about 2.32 mm. long and 1.4 mm. broad. The gular and hypostomal sutures become quite distinct and the gula and maxillary plate from genae. The gula occupies a major portion of the ventral plate and there is no definite line of separation between the former and the maxillary plate. The labium extends posteriorly upto the middle of metasternum. The mesal parts of the sternum become feebly sclerotized. The basisternum with its mesal ridges become fairly distinct. The development of the postphragma becomes

more pronounced. The growth of the first pair of wing buds is rapid than those of the second pair. The first pair of wing lobes extend upto the first abdominal tergum and completely overlaps the second pair. The abdomen has become elongated and the ventral streak in females extends throughout the eight sternum. The duration of this stadium is of four days.

(v) Fifth instar.— In this last instar it has been invariably seen that the growth of the nymph is very rapid. It increases to a maximum length of about 15.2 mm. There is no change in the colour of the body. The head is about 3.24 mm. long and 1.8 mm. broad. There is no remarkable change in the structure of the head. The protergum extends posteriorly and overlaps about half of the mesotergum. The prephragma is faintly marked off while the postphragma has developed immensely. The mesotergum becomes divided into scutum and scutellum, the later extending upto the middle of the metatergum. The wing buds of both pairs have increased in size. The first pair extends upto third abdominal tergum while the second pair ends near the posterior margin of the second abdominal tergum. The sclerotization of the thoracic sternum becomes more pronounced. The paratergites and parasternites of the abdomen have become more distinct. The first valvifer becomes partially developed. The ninth sternum in males shows in its postero-lateral region two large spots which indicate the developing claspers. This nymphal stage lasts for five days and as such becomes the longest stadium.

Newly emerged adult.— The fifth moult brings forth the well develoned adult. The mechanism of eclosion of the adult from the last nymphal skin is similar to that of the preceding ones. In the newly emerged adult there are three things which can be claimed with any certainity as the special features of metamorphosis. Firstly, that the paired ocelli make their first appearance. Secondly, that the openings of the odoriferous glands, which so far in the nymph were placed on the fifth and sixth abdominal terga, close down and become functionless. The functional odoriferous glands of the adult develop and open into the metasternum. Finally, that the third tarsal joint is added. Lefroy (1908) considers this to have become separated from the distal tarsal joint of the nymph. The extension of the protergum over whole of the mesoscutum, the formation of the pleural folds (episternal and epimeral folds), the well developed wings and the external genitalia are few more notable features.

The newly emerged adult is about 16 mm. long and is devoid of any pigmentation. The general colour of the body and wings etc. is creamy white and the wings lie in a folded condition. In about twenty minutes the pigmentation starts and the body becomes green in colour. Gradually the colour deepens first becoming reddish and finally reddish brown. The antennae retain their usual colour (those of nymphs) while the legs at their joints have a slight tinge of black colour. In due course the wings occupy their normal position and lie flat over the abdomen. In

about three to three and a half hours the pigmentation of the body and the tracheation of the wings become complete.

Longevity.— In presence of ample food the male and female lived for a maximum period of 50 and 104 days respectively. The average longevity of male and female is 33 and 55 days respectively. One female which survived for a maximum period of three and a half months was fed on wild grasses during winter days.

The phenomenon of parthenogenesis does not take place in Leptocorisa varicornis.

Delayed emergence.— The present writer placed few clusters of eggs in order to record any case of delayed emergence i.e. passing over the winter season and summer seasons in egg-stage and hatching early during the rainy season, but not a single egg hatched. The non-occurrence of delayed emergence cases and the survival of one female for three and half months lead the present writer to uphold the view maintained by Lefroy (1908) that it hibernates as an image from December to February and that it aestivates from March to June.

TABLE No. 1

Duration of life-history from July to November.

Different stages of life-history.	Duration Days	Temperature in F		Humidity %
		Maximum °F	Minimum °F	
Pre-copulation period.	12-14	88 - 101	66 - 74	65 - 75
Pre-oviposition period.	3- 4	88 - 101	66 - 74	65 - 75
Oviposition period.	2- 3	88 - 101	66 - 74	65 - 75
Incubation period.	4- 5	88 - 101	66 - 74	65 - 75
First instar.	3- 4	88 - 101	66 - 74	65 - 75
Second instar.	2- 3	88 - 101	66 - 74	65 - 75
Third instar.	2- 3	88 - 101	66 - 74	65 - 75
Fourth instar.	4	88 - 101	66 - 74	65 - 75
Fifth instar i.e. period between 4th instar and emergence of adult.	5	88 - 101	66 - 74	65 - 75
Total period from newly emerged adult till emergence of off-spring.	37-45	88 - 101	66 - 74	65 - 75
Longivity :				
(a) male.	33	88 - 101	66 - 74	65 - 75
(b) female.	55	88 - 101	66 - 74	65 - 75.

TABLE No. 2

Average length of body and head of ten nymphs.

Parts of nymph	First instar mm.	Second instar mm.	Third instar mm.	Fourth instar mm.	Fifth instar mm.
Length of body including the head.	2.5	4.5	6.8	10.5	15.2
Length of nymphal head.	0.75	1.08	1.78	2.32	3.24

Application of Dyer's law.— The ratio of increase in the width of the head is 1.4. It was obtained by dividing observed width of each instar by the one which precedes it.

TABLE No. 3

Instars	Observed width of nymphal head	Calculated width of nymphal head		Difference
1st instar.	0.47 mm.	- - - - - - - - -		- - -
2nd instar.	0.7 mm.	0.47 x 1.4	0.65 mm.	0.05 mm.
3rd instar.	1.1 mm.	0.65 x 1.4	0.91 mm.	0.19 mm.
4th instar.	1.4 mm.	0.91 x 1.4	1.27 mm.	0.13 mm.
5th instar.	1.8 mm.	1.27 x 1.4	1.77 mm.	0.3 mm.

The observed width of the first instar was then multiplied by this ratio (1.4) to get the calculated width of the second instar. By multiplying the calculated width of the nymphal head by the ratio, the calculated width of the instar following it was obtained. The difference between the observed and calculated width shows that there is a gradual increase upto third instar but in the later stages this geometrical progression is lost. The present writer is of the opinion that Dyer's law does not hold good in Leptocorisa varicornis. Quadri's (1946) similar findings in Periplanata lead the present author to believe that Dyer's law is not applicable to Hemimetabolous (Exopterygota) insects where the metamorphosis is simple, gradual and direct.

VI. SUMMARY

1. The preceding work includes an account of the external and internal anatomy and life history of Leptocorisa varicornis Fabr. (Coreidae, Heteroptera), a serious pest of paddy cropin India.

2. The various sutures and sclerites of the head capsule have been described. It is shown that the epistomal suture demarcates frons from clypens and the mandibular plates have been regarded as sub-genal sclerites (pleuro-stomae).

3. An account of the antennae and their muscles is given.

4. It is shown that only the posterior tentorial pits and the posterior tentorial arms are present.

5. The mouth parts and their working has been discussed. It is claimed that mandibular plate and lorum are independent sclerites. It is also held that the basal constriction of the labrum and the apical clamp of the labium aid in holding the stylets in position.

6. The hypopharynx, salivary syringe and sucking pump together with their muscles have been narrated. The dorso-lateral processes of the hypopharynx have been termed as lora.

7. The mode of feeding has been described and it is held that the maxillary stylets are the chief piercing organs.

8. It has been shown that the cervical sclerites articulate with the articular processes of the cranium.

9. The different sutures and the sclerites of the thorax have been studied.

10. The structure of the legs together with extrinsic and intrinsic muscles is described in detail. It is shown that the distal end of the tibia of fore legs has become modified and bears the 'antenna cleaner'.

11. The venation of the fore and hind wings, their sclerites and muscles have been studied. It is claimed that the third axillary of fore wing is double.

12. The pregenital, genital and postgenital regions of the abdomen along with the muscles have been described.

13. The female genitalia and its muscles have been described. It is claimed that the third valvula is absent.

14. It is shown that the phallus of the male genitalia includes a sclerotized phallobase and a membranous aedeagus. It is also claimed that the parameral valves and aedeagus are not provided with independent muscles.

15. The harpagones together with muscles have been described.

16. The anatomy and histology of various regions of the alimentary canal have been studied. It is shown that the ventriculus is divided into four parts; the last (distal most) region develops longitudinally the gastric caeca.

17. It has been shown that the histology of the principal and accessory glands and the salivary ducts do not show any marked difference.

18. The histology of the malpighian tubules has been attempted.

19. The vascular system has been studied. It has been held that the ventral diaphragm is absent.

20. The structure of the thoracic and abdominal spiracles has been described. It is shown that the thoracic spiracles open and abdominal spiracles close by their own elasticity.

21. The principal tracheal tubes and their major branches have been described.

22. The brain, the ventral nerve cord and the nerves innervating the various parts of the body have been described.

23. The stomodaeal nervous system also has been worked out.

24. The anatomy of the female reproductive organs has been studied.

25. The histology of the ovariole shows that it is acrotrophic type.

26. The anatomy and histology of various regions of the male reproductive organs has been attempted. It is shown that the lumen of the ejaculatory duct has a cuticular lining.

27. An account of the life history of Leptocorisa is given. Its distribution and food plants have been described.

28. The habits of the adult as well as nymphs and the extent of damage caused to the crop is also observed.

29. The mode of copulation and oviposition has been studied. It is shown that the number of eggs in each cluster varies from fourteen to thirty.

30. An account of the pre-imaginal stages has been given. The duration of the different instars to complete their growth

has been recorded.

31. The mode of emergence of the adults as well as the nymphs has been observed.

32. The longevity and cases of delayed emergence have been described. It has been shown that parthenogenesis does not occur in Leptocorisa.

33. The 'Dyer's law' was applied. It has been stated that it does not hold good in Leptocorisa varicornis.

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VIII. ABBREVIATIONS

Abbreviations used on the figures of head region

af - Antennafer

an - Antennal socket

Ap_1 - Dorsal apodeme of scape

Ap_2 - Ventral apodeme of scape

ap_1 - Dorsal apodeme of second antennal segment

ap_2 - Ventral apodeme of second antennal segment

aplLb - Apical lobe of labium

ar - Antennal ridge

Ark - Articular knob of scape

Ark_1 - Articular knob of pedical

as - Antennal suture

ASc - Antennal sclerite

bcLm - Basal constriction of labrum

bkn - Basal knob of scape

bLbpl - Basal labial plate

bp - Bristle pouch

bs_{1-4} - Antennal stalk

Buc - Bucculae

Cb - Cibarium

Clp - Clypeus

Con - Concavity on antennal rim

Conl - Condyle of ring joint

Cs - Coronal suture

Cs mcs - Coronal-cum-midcranial sulcus

cSdt - Common duct of salivary gland

dlprHphy - Dorso-lateral process of hypopharynx

dmScp - Dorsal margin of scape

E - Eye

ec - Ejection canal

edt - Ejaculatory duct of salivary syringe

epthl - Epithelial layer

es - Epistomal suture

er - Epistomal ridge

f_1 - Fibres from maxillary sac

f_2 - Fibres from hypopharynx

fl - Flagellum

Fclp - Foramen of clypeus

Fmg - Foramen magnum

Fr - Frons

fs - Frontal suture

Ge - Gena

Gu - Gula

Gus - Gular suture

Hs - Hypostoma

hpn - Handle of piston

hs - Hypostomal suture

Lb - Labium

Lb_{1-4} - First to fourth labial segments

LbAp - Labial apodeme

Lbgr - Labial groove

Lbpl - Labial plate

Lm - Labrum

Lo - Lorum

Lmgr - Labral groove

Lum - Lumen of antenna

mci - Mid-cranial inflection

mcs - Mid-cranial sulcus

Mda_1 - Outer arm of mandibular stylet

Mda_2 - Inner arm of mandibular stylet

Mdlvr - Mandibular lever

Mdpl - Mandibular plate

mdprHphy - Mid-dorsal process of hypopharynx

MdS - Mandibular stylet

Mds - Mandibular sac

Mdtn - Mandibular tendon

mHphyl - Median lobe of hypopharynx

mlcLm - Mid-longitudinal concavity of labrum

mprdlw - Median process of dorsolateral wall of labium

Mx Hs - Maxillary plate-cum-hypostoma

Mxlvr - Maxillary lever

Mxpr - Maxillary process

MxS - Maxillary stylet

Mxs - Maxillary sac

npn - Projection in pistons hand

O - Ocellus

Oc - Occiput

OcAp - Occipital apodeme

ocr - Occipital ridge

ocs - Occipital suture

or - Ocular ridge

os - Ocular suture

OSc - Ocular sclerite

PAT - Posterior tentorial arm

Pe - Pedicel

Ph_{1-2} - Anterior and posterior pharynx

pn - Piston

poc - Post-occipital suture

Poc - Post-occiput

pocpr - Post-occipital process

por - Post-occipital ridge

ps - Pleurostomal suture

pt - Posterior tentorial pit

rj - Ring joint

sc - Suction canal

Scp - Scape

Sdt - Salivary duct

SprLbpl - Sclerotized process of labial plate

Ss - Salivary syringe

vmScp - Ventral margin of scape

vprHphy - Ventral process of hypopharynx

vLbS - Ventral sclerite of labium

Musculature of the antennae

Nos.

1(a) - Levator of scape

1(b) - Levator of scape

2 - First depressor of scape

3 - Second depressor of scape

4 - Levator of flagellum

5 - Depressor of flagellum

Musculature of the mouth parts

Nos.

6 - Hypopharyngeal retractor of labium

7 - First retractor of labium

8 - Second retractor of labium

9 - First protractor of labial plate

10 - Second protractor of labial plate

11(a-c) - Proximal, median and distal transverse muscle of first set of labial plate

12 - Second set of transverse muscle of labial plate

13(a-b) - First and second retractor of mandibular stylet

Nos.

14 - Protractor of mandibular stylet

15 - Retractor of maxillary stylet

16(a-c) - First, second and third protractor of maxillary stylet

17 - Dilator of salivary syringe

18 - Principal dilator of sucking pump

19 - Accessory dilator of sucking pump

20 - Dilator of anterior pharynx

21 - Strap-shaped dilator of pharynx

22 - Dilator of posterior pharynx

Abbreviations used on the figures of prothoracic region

aeT_1 - Anterior extension of protergum

amT_1 - Anterior margin of protergum

Antcln - Antenna cleaner

BS_1 - Basisternum

$BTar_1$ - Basitarsus

CvS - Cervical Sclerite

Cx_1 - Procoxa

Cx_1c - Procoxal socket

Cx_1r - Procoxal rim

Epm_1 - Epimeron

Epm_1fl - Epimeral flap

Eps_1 - Episternum

Eps_1fl - Episternal flap

Fe_1 - Femur

FS_1 - Furcasternum

Fu_1 - Furcal arm

fu_1 - Posterior horn-like process

Pcx_1 - Postcoxal bridge

peT_1 - Posterior extension of protergum

$PlAp_1$ - Pleural apophysis

$PlCx_1pr$ - Pleurocoxal process

plr_1 - Pleural ridge

pls_1 - Pleural suture

pmT_1 - Posterior margin of protergum

$Prcx_1$ - Precoxal bridge

Prs_1 - Presternum

$PTar_1$ - Pretarsus

r - External ridge of basisternum

Sc_1 - Sternacosta

Scs_1 - Sternacostal suture

T_1 - Protergum

Tb_1 - Tibia

Tn - Trochantin

TP1L - Tergo-pleural line of fusion

Tr_1 - Trochanter

Musculature of the prothoracic region

Nos.

23 - First levator of the head

24 - Second levator of the head

25 - Indirect levator of the head

26 - Depressor of the head

27 - Promotor-extensor of the head

28 - Depressor-extensor of the head

29 - Retractor of the propectus

30 - Depressor of the pronotum

Abbreviations used on the figures of Thoracic legs

Ap_1 - Thoracic depressor's apodeme of trochanter

Ap_2 - Extensor's apodeme of tibia

Ap_3 - Depressor's apodeme of tibia

Ap_4 - Basitarsal depressor's apodeme

Ap_5 - Pretarsal depressor's apodeme

Ark_1 - Articular knob on distal rim of coxa

Ark_2 - Trochanteral articular knobs of the proximal half

Ark_3 - Median articular knob on distal ventral rim of trochanter

Ark_4 - Articular knob on distal rim of femur

Ark_5 - Articular knob of tibia

aux - Auxillae

bcs - Basicostal suture

Bcx - Basicoxite

Cla - Claw

Con_1 - Concavity for the articulation of coxa with pleurocoxal process

Con_2 - Concavity on coxal rim for the articulation of trochantin

Con_3 - Concavity on femur for the articulation of median knob of trochanter

Con_4 - Concavity on tibia for the articulation of proximal basitarsal end

Con_5 - Concavity for the articulation of proximal end of second tarsal joint

dAppl - Dorsal apodemal plate of trochanter

DdrFe - Distal dorsal rim of femur

$DdrTar_3$ - Distal dorsal rim of pretarsus

DdrTb - Distal dorsal rim of tibia

DdrTr - Distal dorsal rim of trochanter

dmCx - Dorsal margin of coxa

DvrTb - Distal ventral rim of tibia

DvrTr - Distal ventral rim of trochanter

emDvrFe - Emarginated distal ventral rim of femur

gfpl - Genuflexor plate

Lum - Lumen

mrdrCx - Marginal ridge on the distal rim of coxa

miCx - Mesal inflection of coxa

PdrFe - Proximal dorsal rim of femur

PdrTb - Proximal dorsal rim of tibia

PdrTr - Proximal dorsal rim of trochanter

plv - Pulvilli

$PTar_3$ - Pretarsus

PvrBTar - Proximal ventral rim of basitarsus

PvrFe - Proximal ventral rim of femur

PvrTb - Proximal ventral rim of tibia

PvrTr - Proximal ventral rim of trochanter

sp - Spines (Embolium)

Tar_2 - Second tarsal joint

Un - Unguifer

Utr - Unguitractor

vmCx - Ventral margin of coxa

Musculature of the fore legs

Nos.

31 - First promotor of coxa

32 - Second promotor of coxa

33 - Third promotor of coxa

34 - First remotor of coxa

35 - Second remotor of coxa

36 - Tergal depressor of trochanter

37 - Pleural depressor of trochanter

38 - Coxal depressor of trochanter

39 - Levator of trochanter

40 - Femoral reductor

41 - Extensor of tibia

42 - Depressor of tibia

43 - Depressor of tarsus

44 - Depressor of pretarsus

Abbreviations used on the figures of mesothoracic region

a - Anterior curved ridge of mesoepisternum

ak - Anterior knob of second axillary sclerite

Abp_1 - Basal plate of anal vein of fore wing

ANP_2 - Anterior notal wing process

Antlm - Anterior lamella of meso-postphragma

$ApSa_2$ - Apodeme of subalare sclerite

1Ax - First axillary sclerite of fore wing

2Ax - Second axillary sclerite of fore wing

3Ax - Third axillary sclerite of fore wing

Axc_1 - Axillary cord of fore wing

b - Posterior ventral ridge of mesoepisternum

Ba_2 - Basalare

Ba_2Ap - Basalare apodeme

BS_2 - Basisternum

$BTar_2$ - Basitarsus

c - Anterior dorsal ridge of mesoepisternum

cAx_2 - Cord from second Axillary sclerite

$ConAx_2$ - Concavity for articulation of second axillary sclerite

Cx_2 - Mesocoxa

Cx_2c - Coxal socket

Cx_2r - Coxal rim

d - Marginal ridge of meso-episternum

$dvcEpm_2$ - Dorso-ventral carina of epimeron

em - Emargination of second axillary sclerite

emr - Emargination of prephragma

Epm_2 - Epimeron

Epm_2fl - Epimeral flap

Eps_2 - Episternum

Eps_2fl - Episternal flap

Fe_2 - Femur

FS_1 - Furcasternum

Fu_1 - Mesofurcal arm

h - Head of third axillary sclerite

HP_2 - Humeral plate of fore wing

Isgr - Intersegmental groove

kb - Posterior knob of epimeron

l - Antero-lateral process of first axillary sclerite

m_1 - Anterior median plate of fore wing

m_2 - Posterior median plate of fore wing

Me - Emargination in first axillary sclerite

mf - Median furrow of mesoscutum

$miEpm_2$ - Mesal inflection of epimeron

mr - Median ridge of prephragma

OBS_2pl - Oblong basisternal plate

p - Mesal process in anterior narrow part of first axillary sclerite

p_1 - Posterior process in anterior narrow part of first axillary sclerite

PAB - Postalar bridge

pg - Posterior groove of mesoscutum

1Ph - Prephragma

2Ph - Mesopostphragma

pk - Posterior knob of second axillary sclerite

PlCxpr - Pleurocoxal process

pls_2 - Pleural suture

PN_2 - Postnotum

PNP_2 - Posterior notal wing process

Postlm - Posterior lamella of meso-postphragma

PrAB - Prealar bridge

Prsc - Prescutum

Prscl - Prescutal lobe

$PTar_2$ - Pretarsus of mesothoracic leg

PWP_2 - Pleural wing process

r_1 - Proximal arm of third axillary

r_2 - Distal arm of third axillary

rPh_2 - Ridge of mesopostphragma

rvs - Reversed notal suture

Sc_2 - Sternacosta

Scl_2 - Mesoscutellum

scl_2 - Lateral scutellar plate

Sct_2 - Scutum

sct_2 - Lateral mesoscutal plate

sp_1 - Mesothoracic spiracle

sp_2 - Metathoracic spiracle

$splSa_2$ - Supporting plate of subalare

Tb_2 - Tibia

Tr_2 - Trochanter

ts - Prescutal suture

vs - Trans-scuto-scutellar suture

x - External ridge of basisternum

Y - Internal ridge of basisternum

Musculature of the mesothoracic wings

Nos.

45 - Indirect and principal depressor of fore wings

46 - Secondary indirect depressor of fore wings

47 - Indirect and principal levator of fore wings

48 - Secondary indirect levator of fore wings

49 - Flexor of fore wings

50 - Promotor-extensor of fore wings

51 - Depressor-extensor of fore wings

52 - Intersternal muscle between pro- and mesosternal apophysis

Musculature of the mesothoracic legs

53 - First promotor of coxa

54 - Second promotor of coxa

55 - First remotor of coxa

56 - Second remotor of coxa

57 - Tergal depressor of trochanter

58 - Pleural depressor of trochanter

Abbreviations used on the figures of metathoracic region

Abp_2 - Basal plate of anal vein of hind wing

aem - Anterior emargination of median ridge of sternal apophysis

anH - Antero-dorsal lobe of episternum

AMP_3 - Anterior notal wing process

1Ax - First axillary sclerite

2Ax - Second axillary sclerite

3Ax - Third axillary sclerite

Axc_2 - Axillary cord of hind wing

Ba_3 - Basalare

bmr - Basal median ridge of sternal apophysis

BS_3 - Basisternum

$BTar_3$ - Basitarsus

Cx_3 - Hind coxa

Cx_3c - Coxal socket

Cx_3r - Coxal rim

em - Emargination of metascutum

Epm_3 - Epimeron

Epm_3fl - Epimeral flap

Epm_3fld - Epimeral fold

Eps_3 - Episternum

Eps_3fl - Episternal flap

Fe_3 - Femur

FS_3 - Furcasternum

Fu_3 - Sternal anophysis

h - Head of third axillary sclerite of hind wing

HP_2 - Humeral plate of hind wing

i - Inner process of first axillary sclerite of hind wing

$iaSct_3$ - Inner arm of metascutum

Ismb - Intersegmental membrane

k - Mesal process of inner margin of subalare

MP - Median plate of hind wing

mplfl - Metapleural flap

n - Median notch of metascutum

o - Outer process of first axillary sclerite of hind wing

$oaSct_3$ - Outer arm of metascutum

oStgl - Opening of stink gland

3Ph - Metathoracic phragma

$PlCx_3pr$ - Pleurocoxal process

plr_3 - Pleural ridge

pls_3 - Pleural suture

PNP_3 - Posterior notal wing process

$Prcx_3$ - Precoxal bridge

prmr - Process of the median ridge of metasternal apophysis

$PScl_3$ - Metapostscutellum

$PTar_3$ - Pretarsus

PWP_3 - Pleural wing process

r - Sub-marginal ridge of lateral metascutal plate

r_1 - Distal arm of third axillary sclerite of hind wing

r_2 - Proximal arm of third axillary sclerite of hind wing

Sa_3 - Subalare

Scl_3 - Metascutellum

Sct_3 - Metascutum

sct_3 - Lateral metascutal plate

Stfld - Stink folds

Stgr - Stink groove

T_3 - Metanotum

Tb_3 - Tibia

TPlL - Tergo-pleural line of fusion

Tr_3 - Trochanter

vs - Pseudo-scuto-scutellar suture

Musculature of the metathoracic wings

Nos.

59 - Indirect depressor of hind wings

60 - Flexor of hind wings

61 - Depressor-extensor of hind wings

62 - Dilators of odoriferous sacs

Musculature of the metathoracic legs

63 - First promotor of coxa

64 - Second promotor of coxa

65 - Third promotor of coxa

66 - First remotor of coxa

67 - Second remotor of coxa

68 - Tergal depressor of trochanter

69 - Pleural depressor of trochanter

Abbreviations used on the figures of fore wings

a - Costellan cell
af - Anal fold
An - Anal vein
b - Subcostellan cell
C - Costa
c - Basal radial cell
cl - Clavius
CO - Corium
Cu - Cubitus
d - Distal radial cell
e - Medial cell
em - Embolium
f - Cubital cell
M - Media
mb - Membrane
mf - Medial furrow
R - Radius
r-m - Radio-medial cross vein
Sc - Subcosta
Sc R - Subcosta Radius

Abbreviations used on the figures of hind wing

af - Anal fold
An - Anal vein
C - Costa
Cu - Cubitus
Cu_1 - Cubitus one
Cu_2 - Cubitus two
g - Costellan cell
h - Subcostellan cell
i - Radial cell
j - Anterior medial cell
k - Posterior medial cell
l - Anterior cubital cell
m - Posterior cubital cell
M - Media
M_1 - Media one
M_2 - Media two
n - Anal cell
R - Radius
Sc - Subcosta

Abbreviations used on the figures of abdominal region

Ac_1 - Antecostal ridge of first tergum

Ac_2 - Antecostal ridge of second tergum

Ac_5 - Antecostal ridge of fifth sternum

ac_2 - Antecostal ridge of second sternum

acs - Antecostal suture of second tergum

acs_5 - Antecostal suture of fifth sternum

adw - Antero-dorsal wall of proctiger

almlT - Anterolateral margin of first tergum

amlllStn - Antero-mesal lobe of second sternum

amvst - Anterior margin of vestibule

atg_1 - Acrotergite of first tergum

aSt_2 - Acrosternite of second sternum

aSt_5 - Acrosternite of fifth sternum

cjm - Conjunctival membrane

emlT - Emarginated margin of first tergum

Ism - Intersegmental membrane

n - Antero-ventral process of ninth tergum of male

p - Antero-ventral articular knob of ninth tergum of female

pemVIIStn - Posterior emarginated margin of seventh sternum of male

peIXT - Posterior emargination of ninth tergum of male

pmlVIIStn - Posterior mesal lobe of seventh sternum of female

pmvst - Posterior margin of the vestibule

prtg - Proctiger

$pStn_{2-7}$ - Second to seventh parasternites

pT_{2-8} - Second to eighth paratergites

Sap - Supra-anal plate of vestibule

sap - Sub-anal plate of vestibule

sp - Spiracle

II-IXStn - Second to ninth abdominal sternites

I-IXT - First to ninth abdominal tergites

Musculature of the abdomen

70 - Outer row of inter-tergal muscle of first tergum

71 - Inner row of inter-tergal muscle of first tergum

72 - Outer row of inter-tergal muscle of second tergum

73 - Inner row of inter-tergal muscle of second tergum

74 - Outer row of inter-tergal muscle of seventh tergum

75 - Outer row of inter-tergal muscle of eighth tergum

76 - Inter-sternal muscle of second sternum

77 - Inter-sternal muscle of a typical sternum

78 - Tergo-sternal muscle of a typical segment

79 - Abductor muscle of supra-anal plate

Abbreviations used on the figures of female genitalia

amlVlf - Anterior margin of first valvifer

AplVlf - Antero-dorsal apodeme of first valvifer

BsVl - Basivalvula

dmlVl - Dorsal margin of first valvula

dmlVlf - Dorsal margin of first valvifer

gr - Groove of the first valvula

irlVl - Inner ramus of first valvula

m - Narrow plate of inner ramus of the first valvula

mr - Marginal ridge of first valvula

n - Antero-ventral process of the ninth tergum of female

orlVl - Outer ramus of first valvula

p - Antero-ventral articular knob of the ninth tergum of female

pmlVlf - Posterior margin of first valvifer

q - Dorsal articular concavity of the second valvifer

smr_1 - Submarginal ridge of first valvula

smr_2 - Submarginal ridge of second valvula

1Vl - The first valvula

2Vl - The second valvula

1Vlf - The first valvifer

2Vlf - The second valvifer

vmlVl - Ventral margin of first valvula

vmlVlf - Ventral margin of first valvifer

Musculature of the female genitalia

80 - Principal depressor of first valvifer

81 - Accessory depressor of first valvifer

82 - Principal levator of second valvifer

83 - Accessory levator of first valvifer

84 - Anterior muscle of second valvifer

85 - Posterior muscle of second valvifer

Abbreviations used on the figures of male genitalia

Aed - Aedeagus

Aedap - Aedeagal apodeme

ap_1 - An apodeme arising from the inner lobe of basal plate

ap_2 - An apodeme ending on the proximal half of phallobase

avpr - Antero-ventral process of aedeagus

bClp - Broad base of clasper

bfPhb - Basal fold of phallobase

Bpl - Basal plate of phallobase

Clp - Clasper (harpagone)

Dej - Ductus ejaculatorius

dPhb - Distal half of phallobase

dpr - Dorsal process of aedeagus

DTr - Dorsal transverse process

ilBpl - Inner lobe of basal plate of phallobase

kb - Knob at the distal end of harpagone

mb - Conjunctival membrane

mPPh - Median periphallic process

mpr - Median process of aedeagus

obpl - Oblong plate of phallobase

olBpl - Outer lobe of basal plate of phallobase

Phb - Phallobase

prPhb - Proximal half of phallobase

PrV - Parameral valves

Vr - Virga

Musculature of the male genitalia

86 - Extensor muscle of phallus

87a - Principal retractor muscle of phallus

87b - Accessory retractor muscle of phallus

88 - Adductor muscle of harpagone

Abbreviations used on the figures of digestive system

An - Anus

aSgl - Accessory salivary gland

b - Globules

Bmb - Basement membrane

Bmb_1 - Basement membrane of the anterior intestine

Bmb_2 - Basement membrane of the posterior intestine

cml - Circular muscle layer

Cr - Crop

CVlv - Cardiac valve

dgc - Digestive cells

Epth - Epithelial layer

g - Constriction between the fourth stomach and intestine

h - Hairs facing lumen in crop

In - Intima

Int - Intestine

k - Constriction between the anterior and posterior intestines

lml - Longitudinal muscle layer

Lum - Lumen

nu - Nucleus

Oe - Oesophagus

prs - Peritoneal sheath

pSgl - Principal salivary gland

Pvent - Proventriculus

PVlv - Pyloric valve

Rect - Rectum

rgc - Regenerative cells

RVlv - Rectal valve

Sb - Striated border

Sdt - Salivary duct

$Vent_{1-4}$ - First to fourth ventriculus

Abbreviations used on the figure of excretory system

BMb - Basement membrane
cp - Ciliary processes
Epth - Epithelial layer
Lum - Lumen
mt_{1-4} - Malpighian tubules
nu - Nucleus

Abbreviations used on the figure of vascular system

Ao - Aorta
ddph - Dorsal diaphragm
Ht - Heart
Oe - Oenocytes
os - Ostia

Musculature of the diaphragm

89, 90 and 91 - Alarymuscles

Abbreviations used on the figures of respiratory system

(SPIRACLES)

ap - Outer aperture of abdominal spiracle
aw - Anterior wall of abdominal spiracle
L_{1-2} - Anterior and posterior opercula of mesothoracic spiracle
mnb - Manubrium
op_{1-2} - Anterior and posterior opercula of metathoracic spiracle
per_1 - Peritreme of mesothoracic spiracle
per_2 - Peritreme of metathoracic spiracle
pr_1 - Sclerotic lobe of the mesothoracic spiracle
pr_2 - Sclerotic lobe of the metathoracic spiracle
pStn - Parasternite
pw - Posterior wall of abdominal spiracle
r_1 - Ridge on the peritreme of mesothoracic spiracle
r_2 - Ridge on the peritreme of metathoracic spiracle

r_3 - Ridge on the parasternite

rd - Marginal ridge of the spiracular aperture

s_1 - Vertical slit-like opening of mesothoracic spiracle

s_2 - Vertical slit-like opening of metathoracic spiracle

sbr - Sclerotic bar on the anterior wall of abdominal spiracle

(TRACHEAE)

adMst - Antero-dorsal mesothoracic trachea

adMtt - Antero-dorsal metathoracic trachea

Ant - Antennal trachea

avMst - Antero-ventral mesothoracic trachea

dlTr - Dorsal longitudinal trachea

dPrt - Dorsal prothoracic trachea

Dt - Dorsal cephalic trachea

Dt_{1-7} - First to seventh dorsal abdominal trachea

dTt_{2-7} - Second to seventh dorsal tergal trachea

$dVst_{1-7}$ - First to seventh dorsal branches of the visceral trachea

dVt_{1-7} - First to seventh dorsal branches of the ventral trachea

Mdt - Mandibular trachea

Mstl - Trachea of mesothoracic leg

Msvt - Mesothoracic ventral trachea

Mttl - Trachea of metathoracic leg

Mxt - Maxillary trachea

Opt - Trachea of the eye

pdMst - Postero-dorsal mesothoracic trachea

pdMtt - Postero-dorsal metathoracic trachea

Prtl - Trachea of prothoracic leg

pThvst - Posterior thoracic visceral trachea

1-2Spt - Meso- and metathoracic spiracular trachea

Spt_{1-7} - First to seventh abdominal spiracular trachea

Thvst - Thoracic visceral trachea

vMtt - Metathoracic ventral trachea

vPrt - Prothoracic ventral trachea

Vst_{1-7} - First to seventh visceral abdominal trachea

VSt_{1-7} - First to seventh sternal branches of the ventral tracheae

Vt - Ventral cephalic trachea

Vt_{1-7} - First to seventh ventral abdominal tracheae

1-3vTCom - Pro-, meso- and metathoracic ventral transverse commissures

$TCom_{1-7}$ - First to seventh abdominal ventral transverse commissures

$vVst_{1-7}$ - First to seventh ventral branches of the visceral tracheae

Musculature of the spiracles

92 - Occlusor muscle of mesothoracic spiracle

93 - Occlusor muscle of metathoracic spiracle

94 - Dilator muscle of abdominal spiracle

Abbreviations used on the figures of Nervous system

a - Anterior nerve arising from the prothoracic ganglion

Ab - Abdominal ganglionic centre

I-IXAbN - First to ninth abdominal nerves

AntGng - Antennal ganglion

Ant N - Antennal nerve

b - Second nerve originating from the prothoracic ganglion

1Br - Protocerebrum

2Br - Deutocerebrum

3Br - Tritocerebrum

3BrCom - Tritocerebral commissure

c - Posterior nerve arising from the prothoracic ganglion

Ca - Corpora allatum

cf - Circular furrow demarcating optic lobe from protocerebrum

CoeCon - Circum-oesophageal connective

d - First nerve originating from the mesothoracic ganglionic centre

e - Second nerve arising from the mesothoracic ganglionic centre

f - Third nerve arising from the mesothoracic ganglionic centre

f_{1-2} - Anterior and posterior branches of the third nerve originating from mesothoracic ganglionic centre

FrGng - Frontal ganglion

FrLrCon - Fronto-labral connective

FrN - Frontal nerve

g - Anterior nerve originating from metathoracic ganglionic centre

h - Second nerve originating from the metathoracic ganglionic centre

i - Posterior nerve arising from the metathoracic ganglionic centre

i_{1-2} - Outer and inner branches of the posterior nerve originating from the metathoracic ganglionic centre

iGnCon - Inter-ganglionic connective

LbN - Labial nerve

LBN - Labral nerve

M_1 - Mesothoracic ganglionic centre

M_2 - Metathoracic ganglionic centre

Mdn - Mandibular nerve

mf - Median furrow on the mid-dorsal wall of the proto-cerebrum

mN - Median nerve

MxN - Maxillary nerve

OcGng - Occipital ganglion

OcN - Occipital nerve

ON - Ocellar nerve

OpL - Optic lobe

pmFr - Posterior margin of brain

PrthGng - Prothoracic ganglion

Ptth Ab-Gng - Pterothoracic-cum-abdominal ganglion

RN - Recurrent nerve

SGng - Stomachic ganglion

SoeGng - Suboesophageal ganglion

Abbreviations used on the figures of female reproductive organs

Acgl - Accessory glands

Clx - Calyx

eml - Circular muscle layer

Epth - Epithelial layer

Fcl - Follicular cells

Gc - Genital chamber

Gpr - Gonopore

Grm - Germarium

Int - Inner tunica

lml - Longitudinal muscle layer

lOd - Lateral oviduct

Lum - Lumen

Nrcl - Nerse cells

ns - Plasmatic strands

Ode - Oviductus communis

Ooc - Oocytes

Ov - Ovary

Ovl - Ovariole

prs - Peritoneal sheath

Spt - Spermatheca

TF - Terminal filament

Vtl - Vitellarium

Abbreviations used on the figures of male reproductive organs

Acgl - Accessory gland

Bmb - Basement membrane

ch - Curved hook-like process

cIn - Circular intima

cml - Circular muscle layer

Dej - Ductus ejaculatorius

Epth - Epithelial layer

epth - Epithelial layer of accessory gland

Gpr - Gonopore

iEpth - Inner nucleated epithelial layer

In - Intima

lml - Longitudinal muscle layer

Lum - Lumen

oEpth - Outer non-nucleated epithelial layer

prs - Peritoneal sheath

Rd - Reduction division

Spd - Spermatids

SpT - Sperm tube

Spz - Spermatozoa

Stg - Spermatogonia

Tes - Testis

Vd - Vas deferens

Ve - Vas efferens

vg - Virga

Vsm - Vesicula seminalis

Zg - Zone of growth

IX. EXPLANATION OF FIGURES

Explanation of the figures pertaining to the 'cephalic region

Fig.1. Dorsal view of the head capsule.

Fig.2. Lateral view of the head capsule.

Fig.3. Ventral view of the head capsule.

Fig.4. Posterior view of the head capsule.

Fig.5. Ventral view of the labrum.

Fig.6. Lateral view of the antenna.

Fig.7. Outer view of the antennal socket.

Fig.8. Dorsal view of the scapo-pedicelar articulation.

Fig.9. Ventral view of the scapo-pedicelar articulation.

Fig.10. Dorsal view of the joint between pedical and third antennal segment.

Fig.11. Dorsal view of the joint between third and fourth antennal segment.

Fig.12. Dorsal view of the joint between ring-joint and flagellum.

Fig.13. Proximal rim of scape with lumen facing sky, and muscles.

Fig.14. Dorsal view of scapo-pedicelar articulation with muscle.

Fig.15. Ventral view of scapo-pedicelar articulation with muscle.

Fig.16. Inner view of dorsal wall of cranium with extrinsic muscles of antenna.

Fig.17. Dorsal view of the labium.

Fig.18. Ventral view of the labium.

Fig.19. Dorsal view of the apical segment of labium.

Fig.20. Lateral view of the labium with muscles.

Fig.21. The mandibular stylet with lever.

Fig.22. Apex of mandibular stylet (magnified under oil immersion).

Fig.23. Inner view of distal right half of the head capsule showing articulation of the mandibular lever.

Fig.24. Inner view of right half of head capsule with mandibular muscles.

Fig.25. The maxillary stylet with lever.

Fig.26. Apex of maxillary stylet (magnified under oil immersion).

Fig.27. Inner view of right half of the head capsule showing articulation of the maxillary lever.

Fig.28. Inner view of right half of the head capsule with maxillary muscles.

Fig.29. T.S. of mandibular and maxillary stylets (under oil immersion).

Fig.30. Dorsal view of hypopharynx showing lorum and mandibular plate.

Fig.31. Ventral view of hypopharynx showing its relation with salivary syringe.

Fig.32. Lateral view of salivary syringe with salivary duct.

Fig.33. The hypopharynx and salivary syringe with its muscle.

Fig.34. The stylets, hypopharynx and salivary syringe in situ.

Fig.35. Lateral view of mid-dorsal process of hypopharynx and pharynx showing muscles.

Explanation of the figures pertaining to the 'thoracic'region.

Fig.36. Dorsal view of the prothorax.

Fig.37. Lateral view of the prothorax.

Fig.38. Ventral inner view of the prothorax.

Fig.39. Lateral inner view of prothorax showing muscles.

Fig.40a. Prothoracic leg.

Fig.40b. Mesothoracic leg.

Fig.40c. Metathoracic leg.

Fig.41. Proximal half of the fore coxa.

Fig.42. Lumen of distal half of fore coxa facing sky.

Fig.43. Dorsal view of the trochanter showing coxo-trochanteral articulation.

Fig.44. Ventral view of proximal half of the femur.

Fig.45. Ventral view of distal half of the femur.

Fig.46. Dorsal view of the femoro-tibial joint.

Fig.47. Ventral view of proximal half of the tibia.

Fig.48. Distal half of tibia showing articulation with basitarsus.

Fig.49. Ventral wall of distal half of fore-tibia with antenna cleaner.

Fig.50. Lateral view of joint between basitarsus and second tarsal joint.

Fig.51. Dorsal view of the pretarsus.

Fig.52. Ventral view of the pretarsus.

Fig.53. Lateral inner view of prothorax with muscles of fore leg.

Fig.54. Lateral view of prothorax with few other muscles of fore leg.

Fig.55. Proximal half of fore coxa showing the insertion of extrinsic muscles of fore leg.

Fig.56. The coxa and trochanter with intrinsic muscles.

Fig.57. Dorsal view of proximal half of the tibia with muscle.

Fig.58. Ventral view of proximal half of the tibia with muscle.

Fig.59. Ventral view of tibio-tarsal joint with muscle.

Fig.60. Lateral view of femur and tibia showing pretarsal muscles.

Fig.61. Dorsal view of the mesotergum.

Fig.62. Lateral view of the mesonectus.

Fig.63. Ventral view of the mesonectus.

Fig.64. Inner view of the mesothorax with muscles of fore wing.

Fig.65. Inner view of mesothorax with extrinsic muscles of leg.

Fig.66. Inner view of mesothorax with another set of muscles of leg.

Fig.67. Proximal half of mesocoxa with muscles.

Fig.68. Dorsal view of the metanotum.

Fig.69. Lateral view of the metathorax.

Fig.70. Ventral view of the metathorax.

Fig.71. Lateral inner view of metathorax with muscles of hind wing.

Fig.72. Lateral inner view of metathorax with muscles of hind leg.

Fig.73. Lateral inner view of metathorax with muscles of hind leg.

Fig.74. Proximal half of the hind coxa with muscles.

Fig.75. Axillary sclerites of the fore wing.

Fig.76. Basal region of fore wing with axillary sclerites.

Fig.77. Axillary sclerites of the hind wing.

Fig.78. Basal part of hind wing with axillary sclerites.

Fig.79. The fore and hind wings showing wing venation.

Explanation of the figures pertaining to the 'abdominal' region.

Fig.80. Dorsal view of the abdomen of female.

Fig.81. Ventral view of the abdomen of female.

Fig.82. Dorsal view of the posterior half of abdomen of male.

Fig.83. Ventral view of the posterior half of abdomen of male.

Fig.84. Inner view of the dorsal wall showing antecostal elements.

Fig.85. Inner view of typical sternum with acrosternite and antecostal ridge.

Fig.86. Dorso-ventral view of the supra- and infra- anal plates.

Fig.87. First and second abdominal terga with median and lateral inter-tergal muscles

Fig.88. Inner view of the posterior terga of male with inter-tergal muscles.

Fig.89. Inner view of the posterior terga of female showing inter-tergal muscles.

Fig.90. Inner view of the second sternum with inter-sternal muscles.

Fig.91. Inner view of a typical sternum showing inter-sternal muscles.

Fig.92. Lateral view of a typical pre-genital segment showing the tergo-sternal muscle.

Fig.93. Inner view of dorsal wall of proctiger with abductor muscle of supra- anal plate.

Explanation of the figures pertaining to the 'female genitalia'.

Fig.94. Lateral inner view of the female genitalia.

Fig.95. Lateral inner view of female genitalia with second valvifer and second valvula removed, showing muscles.

Fig.96. Lateral inner view of female genitalia with first valvifer and first valvula removed, showing muscles.

Explanation of the figures pertaining to the 'male genitalia'.

Fig.97. Dorsal view of the phallus with ninth tergum, dorsal half of parameral valves and aedeagal membrane removed.

Fig.98. Ventral view of phallus with ventral half of parameral valves and aedeagal membrane removed.

Fig.99. Lateral view of phallus with muscles.

Fig.100. Dorsal view of phallus with muscles.

Fig.101. Harpagone with muscle.

Explanation of the figures pertaining to the 'digestive system'.

Fig.102. The alimentary canal of Leptocorisa varicornis.

Fig.103. T.S. of crop (under oil immersion).

Fig.104. L.S. of proventriculus and ventriculus.

Fig.105. T.S. of ventriculus (under oil immersion).

Fig.106. L.S. of proctodaeum.

Fig.107. The salivary glands.

Fig.108. T.S. of salivary gland.

Fig.109. T.S. of salivary duct.

Explanation of the figures pertaining to 'excretory and vascular systems'.

Fig.110. L.S. of malpighian tubule.

Fig.111. The dorsal vessel with diaphragm and its muscles.

Explanation of the figures pertaining to the 'respiratory system'.

Fig.112. Inner view of the mesothoracic spiracle with occlusor muscle.

Fig.113. Inner view of the metathoracic spiracle with occlusor muscle.

Fig.114. Inner view of a typical abdominal spiracle with muscle.

Fig.115. Dorsal view of the body showing the tracheal system.

Explanation of the figures pertaining to the 'nervous system'.

Fig.116. Dorsal view of the brain.

Fig.117. Ventral view of the brain.

Fig.118. The ventral nerve cord with associated nerves.

Fig.119. Lateral view of the stomodaeal nervous system.

Explanation of the figures pertaining to the 'female reproductive system'.

Fig.120. The female reproductive organs.

Fig.121. L.S. of the ovariole.

Fig.122. T.S. of the oviduct.

Explanation of the figures pertaining to the male reproductive system'.

Fig.123. The male reproductive organs.

Fig.124. T.S. of testis showing number of follicles.

Fig.125. L.S. of a single follicle.

Fig.126. T.S. of vas deferens.

Fig.127. T.S. of proximal half of ejaculatory duct with accessory gland.

Fig.128. T.S. of distal half of the ejaculatory duct.

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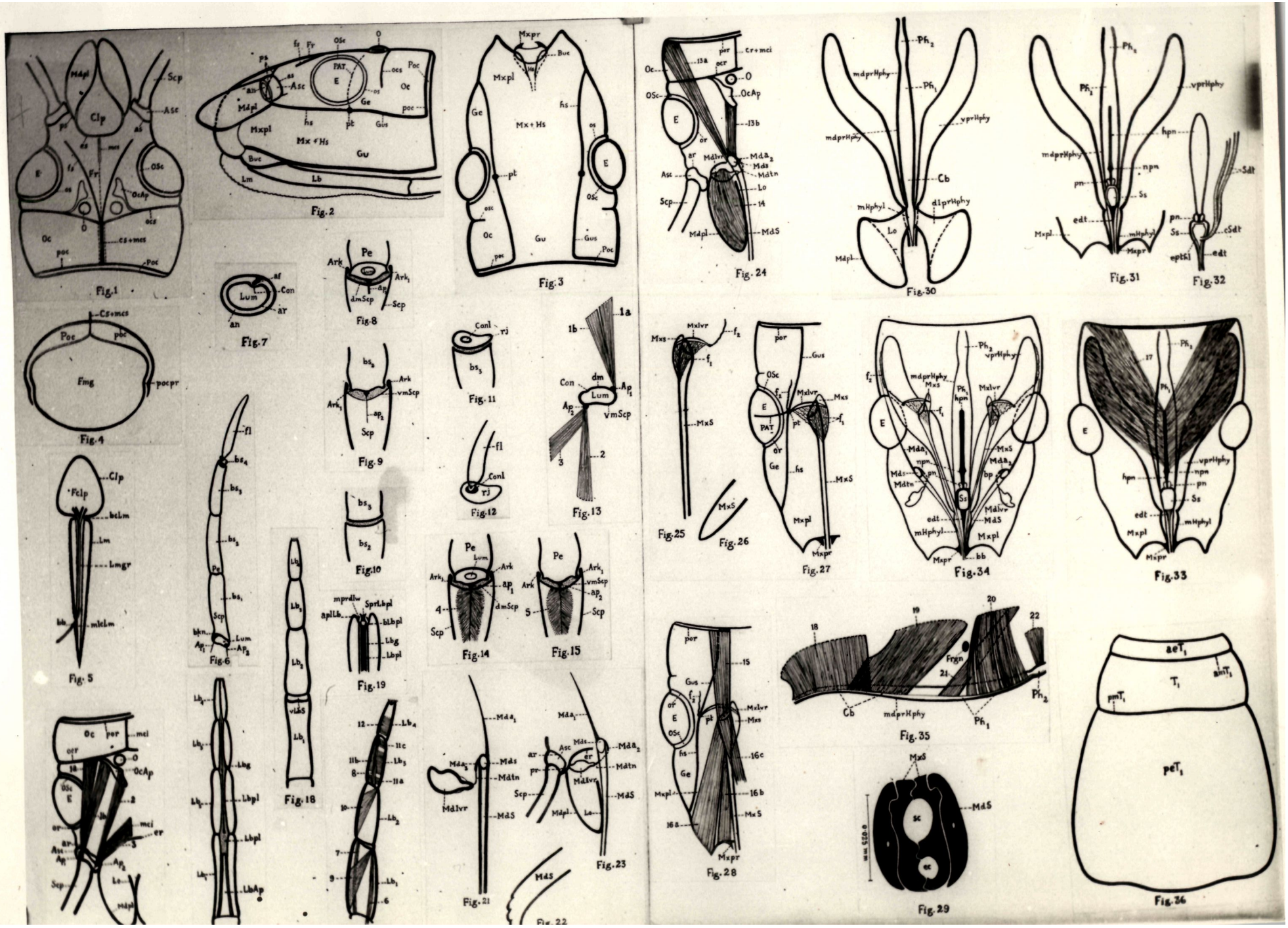
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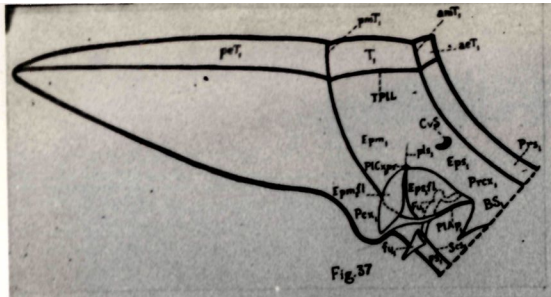

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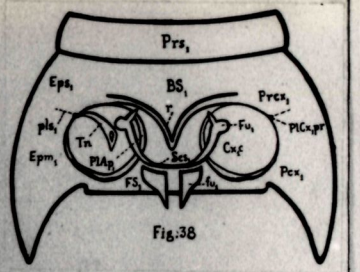

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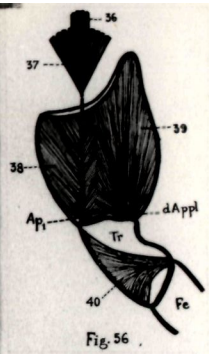

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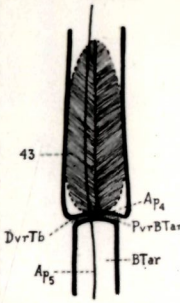

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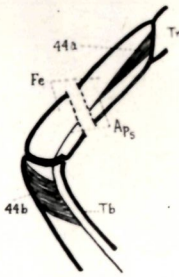

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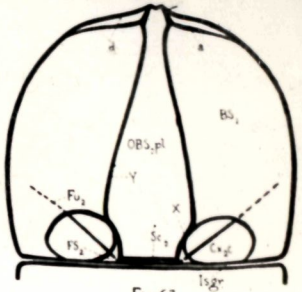

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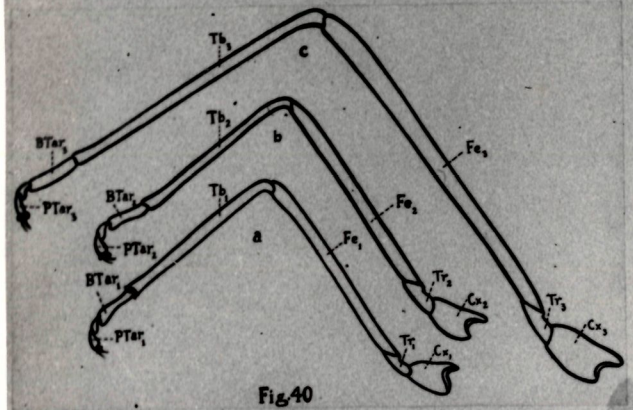

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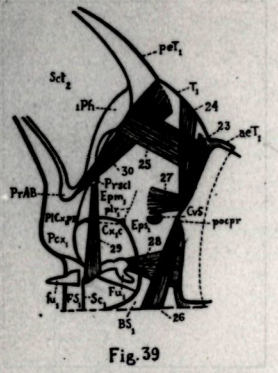

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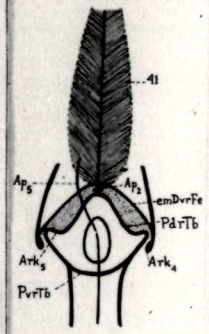
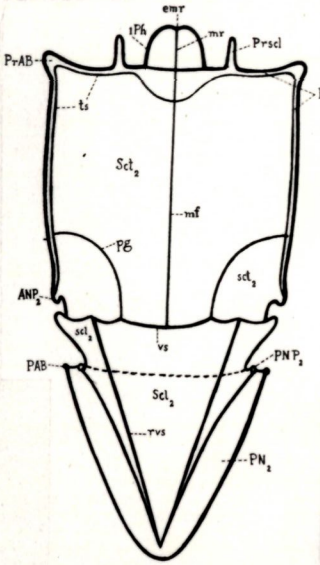


Fig.57



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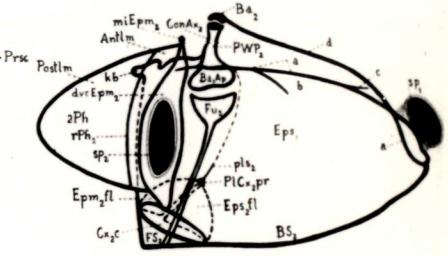

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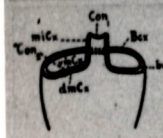

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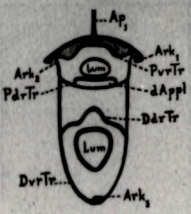

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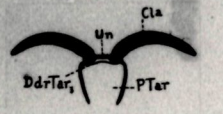

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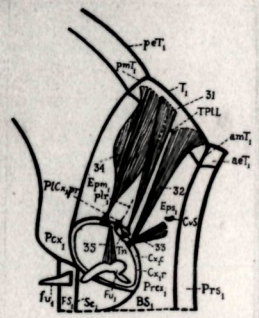

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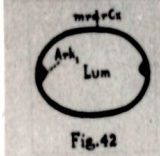

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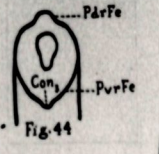
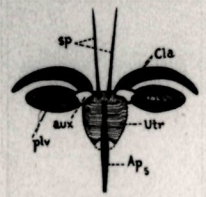


Fig.44

Fig.50



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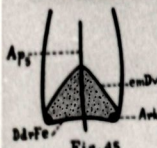

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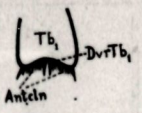


Fig.49

Fig.58

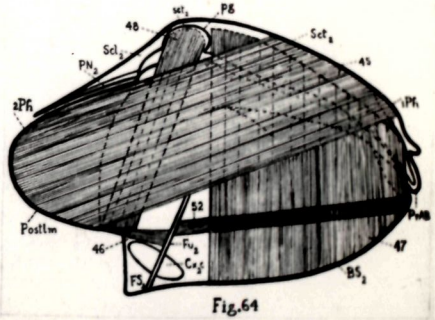
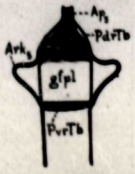


Fig.64

Fig.46



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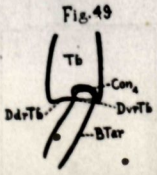

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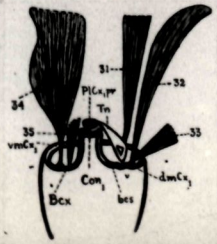

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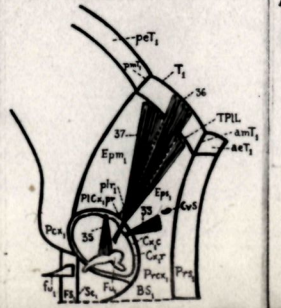

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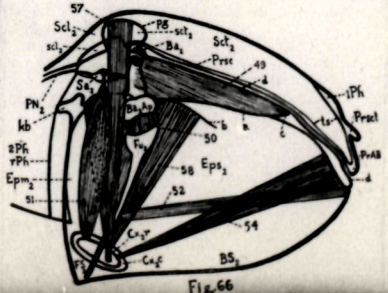

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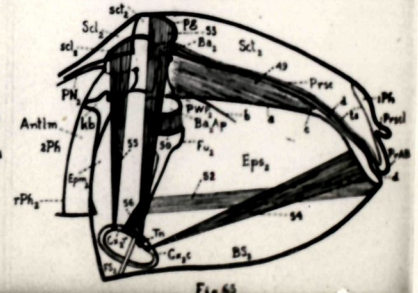

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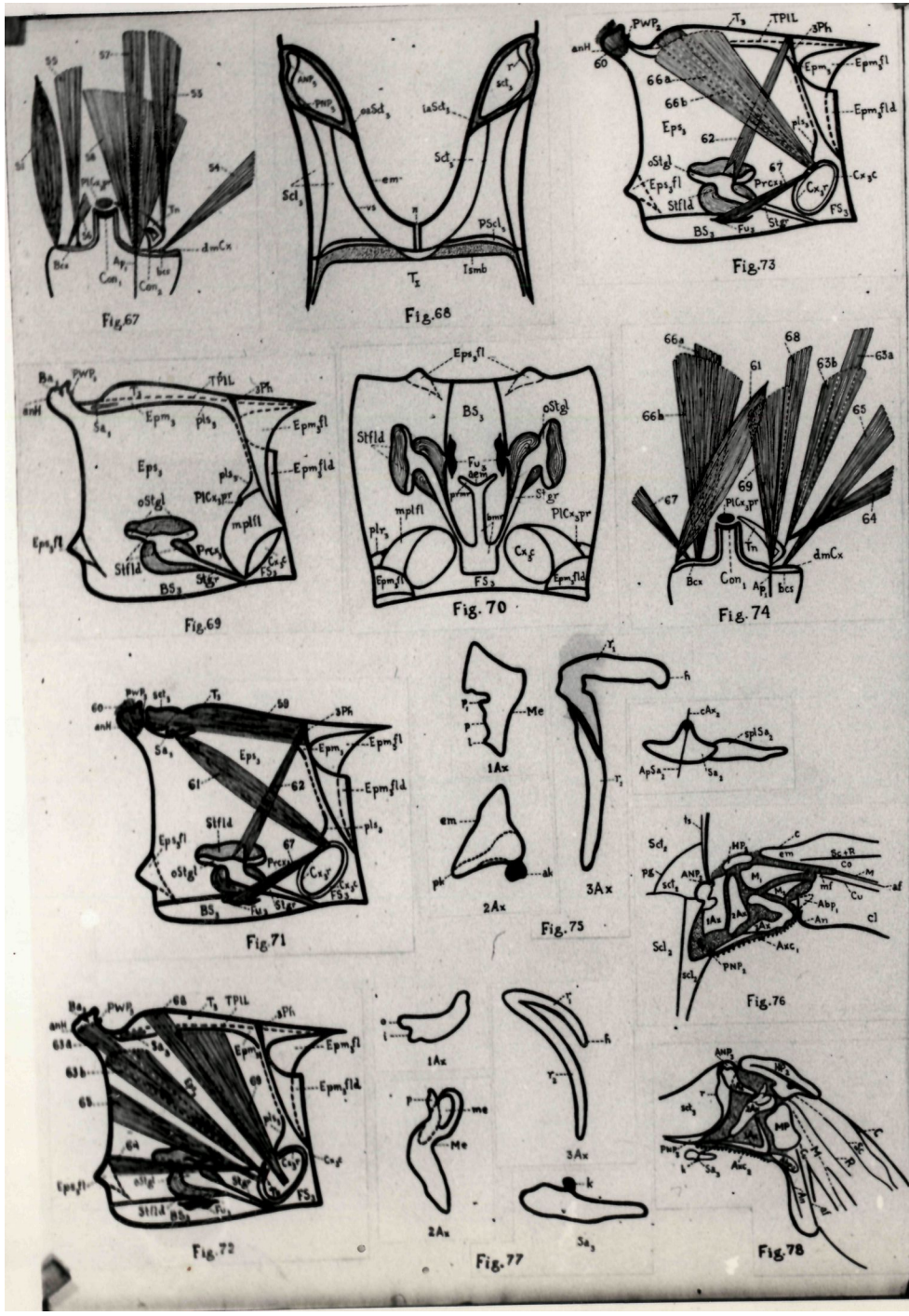
Fig.67
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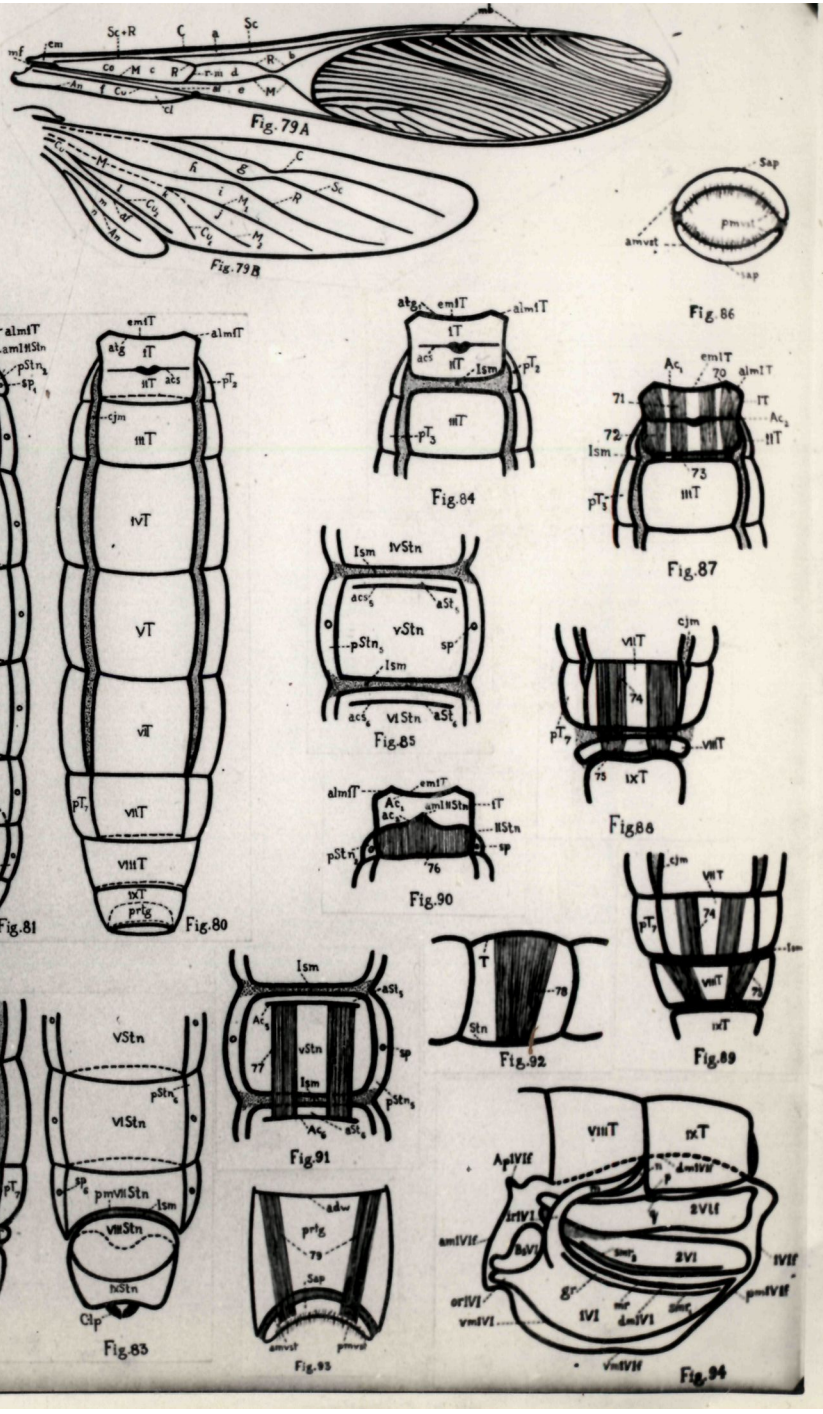
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Fig.79B
Fig.86
Fig.84
Fig.87
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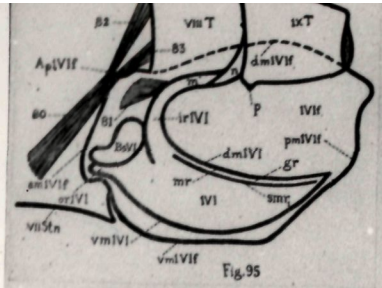

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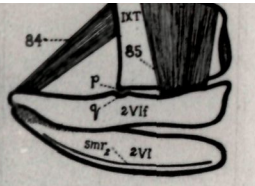

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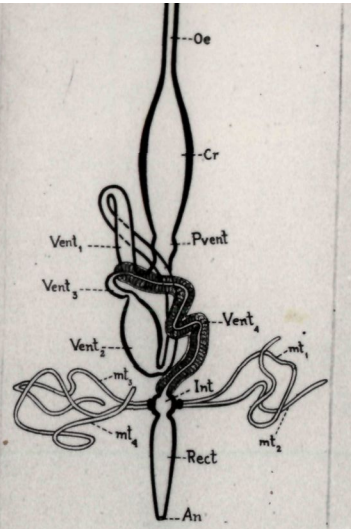

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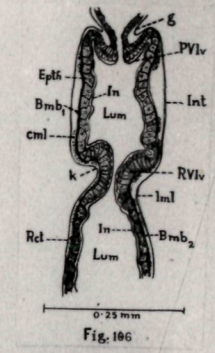
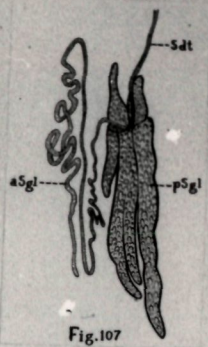


Fig. 106



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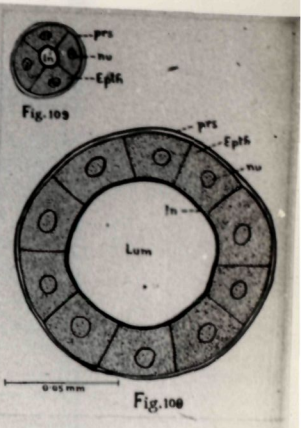
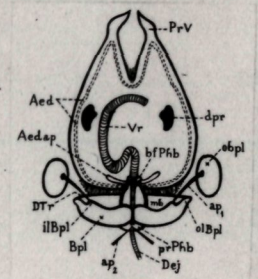


Fig.108

Fig.109

Fig.97



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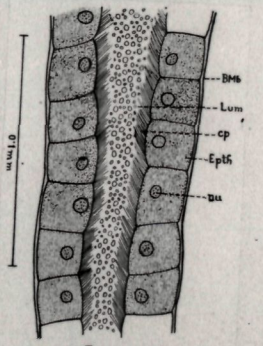

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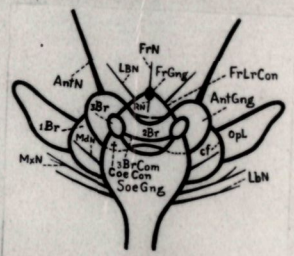

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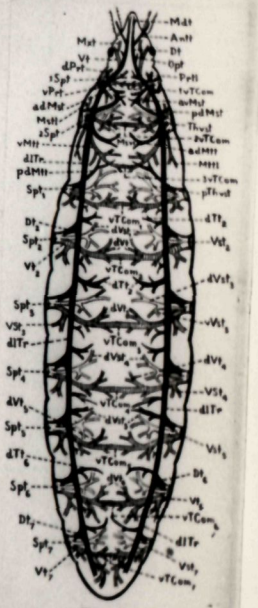
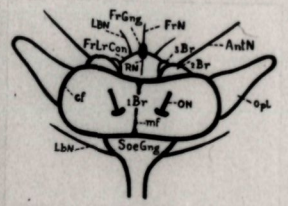


Fig. 115



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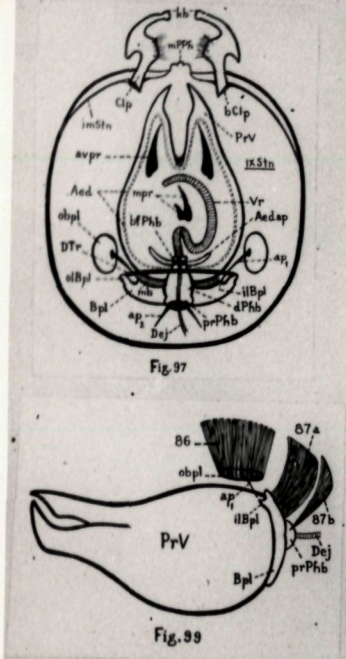

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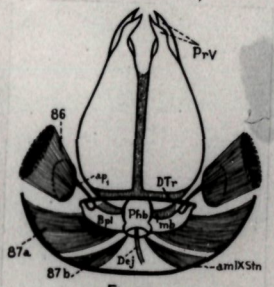
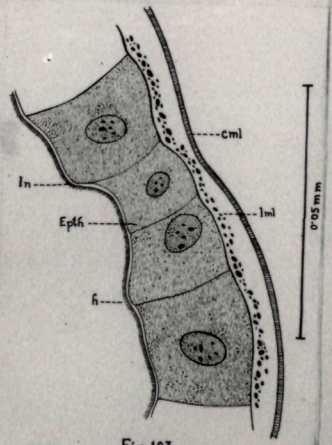


Fig.100



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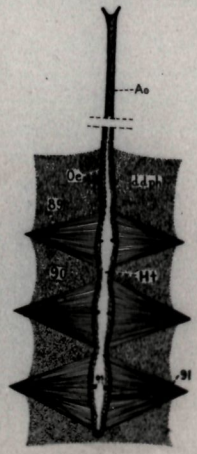

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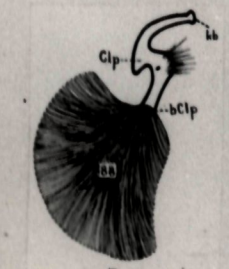

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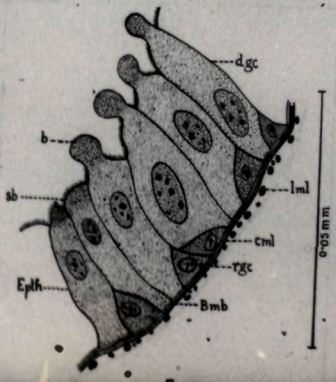

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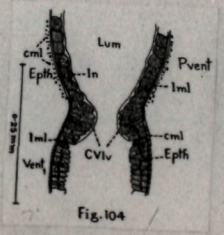


Fig.104

Fig.112

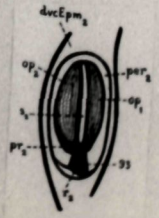


Fig.113

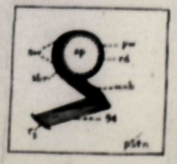
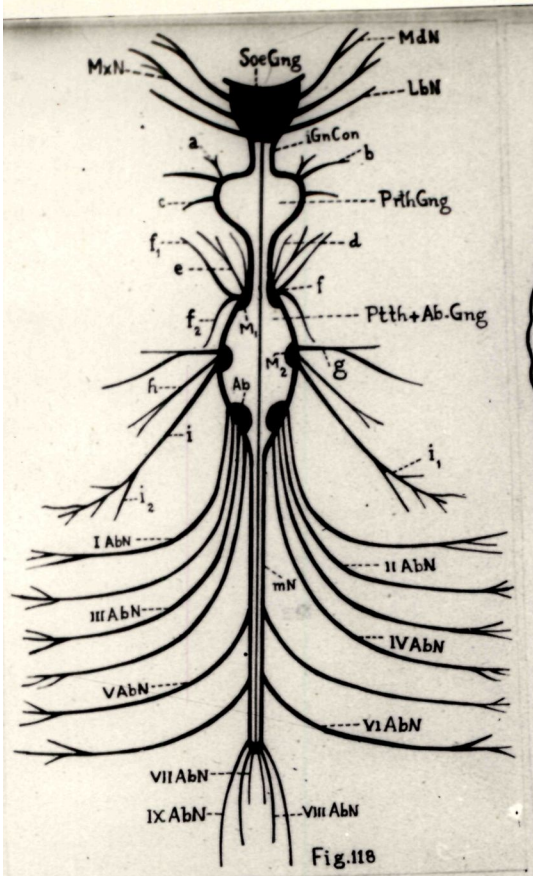


Fig.114



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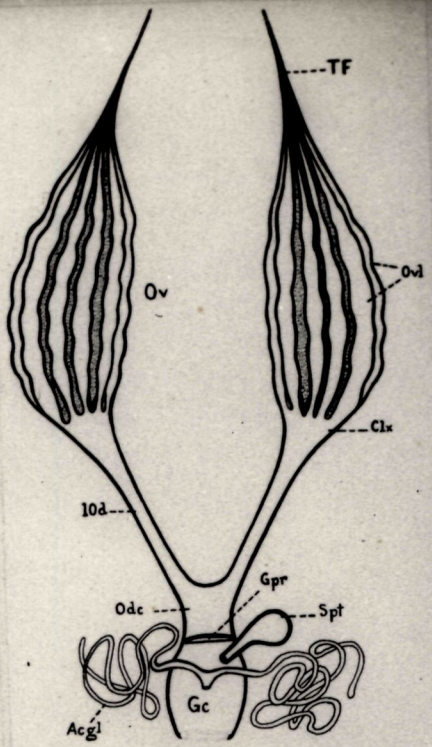

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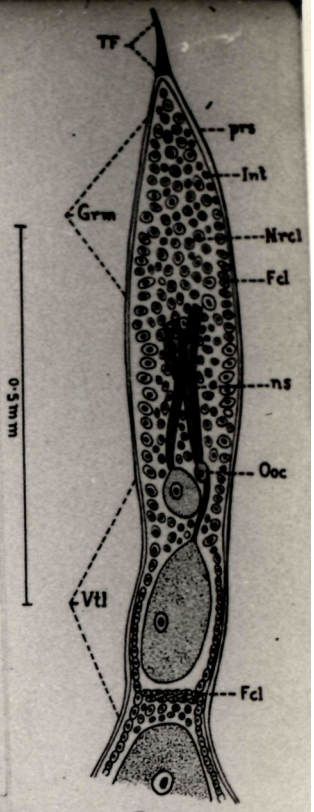

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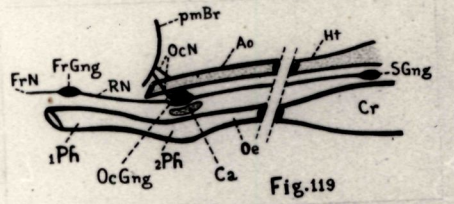

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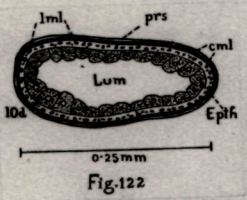
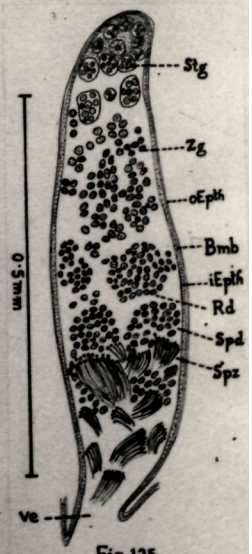


Fig.122



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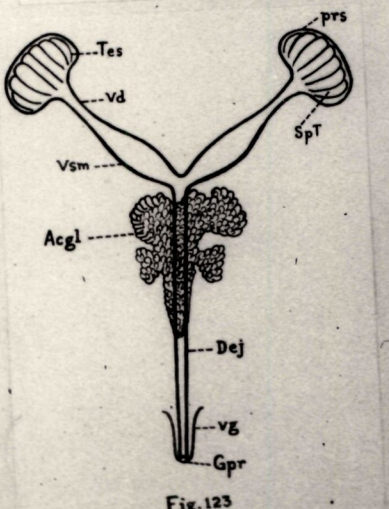
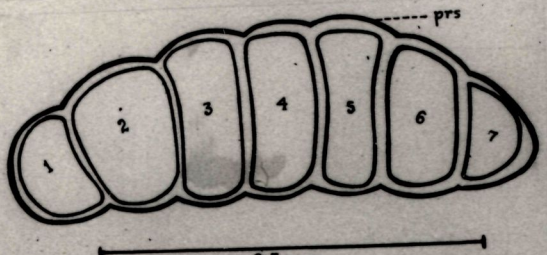


Fig.123



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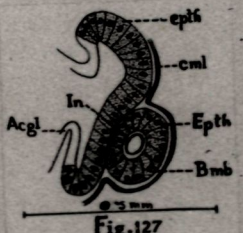

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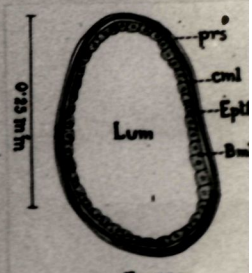

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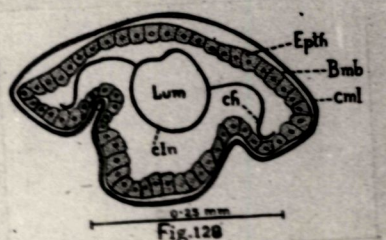

Fig.128